

**WASTE OIL FIRED HEATING SYSTEM
FOR MUNICIPAL WATER
AT HAY RIVER, N.W.T.**

A Feasibility Study

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Prepared for:

Town of Hay River

Prepared by:

Manecon Partnership

With a contribution from:

**Remote Community Demonstration Program
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ABSTRACT

The technical and economic feasibility of a waste oil fired water heating system at the municipal water intake pumphouse at Hay River is assessed. The system is comprised of a waste oil collection system, a pre-treatment system to improve fuel properties of the waste oil, bulk fuel storage and a waste oil fired boiler. The supply of waste oil at Hay River is assessed and found to be of sufficient volume to support the heating of the Town's municipal water supply. Samples of waste oil were obtained from Hay River and analyzed for fuel properties and contaminants. The environmental impact of burning waste oil as a fuel is examined. Capital costs, and operating and maintenance costs for the complete waste oil system are estimated. Installation of a waste oil fired heating system is judged to be viable.

EXECUTIVE SUMMARY

The technical and economic feasibility of a waste oil fired heating system to heat municipal water at Hay River is assessed in this project. Municipal water is drawn from Great Slave Lake and pumped to the Town, located 3 miles south of the pumphouse. During the winter months, December through April, the water must be heated at the pumphouse to avoid freezing in the transmission line. Fuel oil costs for the present system are almost \$100,000 per year. The installation of a waste oil fired heating system described in this report, would effect a significant reduction in the annual heating cost.

The waste oil fired heating system is comprised of several components; including equipment for waste oil collection, pre-treatment, bulk fuel storage and a waste oil fired boiler. A review of literature indicated that serious technical and operational problems are associated with burning waste oil. These problems are attributed to solids and water contamination of the waste oil. Pretreatment for removal of solids and water was judged to be necessary for the system at Hay River to minimize the effects of this contamination. A fire tube boiler and rotary cup burner were selected as being the equipment most suited for waste oil combustion.

Emissions of hazardous contaminants and the potential environmental impact from burning waste oil are also assessed in this project. The occurrence of hazardous contaminants in waste oil collected at Hay River is expected to be low for several reasons:

- o Almost 40% of the total volume of waste hydrocarbons identified at Hay River are fuels contaminated with water and other non-hazardous substances.

- o Incidence of used automobile oil is very low, representing 5% of total volume of waste oil available. Lead is the major contaminant of concern and is associated only with leaded fuels and lubricating oils from vehicles using leaded fuels. All other used oils identified at Hay River originated in diesel (eg. non-leaded fuel) engines.
- o Hay River is a major transportation centre, and most waste oil generated at Hay River will occur within this sector. Major industrial contamination of waste oil (i.e. chlorinated solvents) is less likely to occur at Hay River than in larger urban centres.

A survey was conducted to assess volumes and types of waste oil generated at Hay River. Samples of waste oil were obtained. Analyses of the samples showed good fuel properties (except water content) and low concentrations of hazardous contaminants.

Generally, emissions of lead, barium, and hydrogen chloride have a potentially significant impact on the environment (eg. air quality). However, in this instance, these emissions are not expected to be significant.

This report concludes that the environmental affects of the proposed waste oil burning system, using the waste oil found in Hay River, will be much less than the limits suggested by authorities for safe lifetime exposure.

The capital cost of the waste oil system has been estimated at \$312,000-\$327,100. This includes \$50,000 for a program for monitoring hazardous contaminants in the feed fuel, emissions and residues. This program is assumed to be carried out under the guidance of Environment Canada (EPS).

The operating and maintenance costs of the waste oil system have been estimated as \$23,000 per year. This cost is incremental to operating and maintenance costs of the existing facility. This cost would replace the current fuel costs for the existing facility estimated to be \$96,250 per year, based on a fuel price of 35 cents/litre. Annual savings are therefore \$73,250 per year and the simple payback period on the capital investment is 3.6 - 3.8 years.

The above assumes that waste oil is freely available to the Town. If payment must be made to producers for their waste oil, operating and maintenance costs would increase. The current value of used oil at Hay River is estimated to be 9.8 cents/litre. Assuming this price is paid for 100% of the waste oil fuel, operating and maintenance cost would increase \$26,950, to total \$49,950. Annual savings are reduced to \$46,300 and the simple payback period is increased to 5.7 years.

The waste oil system is suitable for replication at other northern locations. Pine Point, Yellowknife and the Beaufort area are identified as potential sites. Sufficient volumes of waste oil are generated at these locations to support a waste oil fired heating system. Heat generated could be used to heat municipal water (as at Hay River), public buildings or community centres.

The proposed waste oil fired heating system is expected to be a significant improvement, environmentally, in waste oil disposal at Hay River, over the current practices of uncontrolled burning and road oiling.

ÉTUDE DE FAISABILITÉ D'UN SYSTÈME DE CHAUFFAGE
AUX HUILES USÉES POUR UN RÉSEAU D'AQUEDUC MUNICIPAL

HAY RIVER (T.N.-O.)

Résumé

Le présent projet est une évaluation de la faisabilité technique et de la rentabilité d'installer un système de chauffage alimenté aux huiles usées pour chauffer l'eau de l'aqueduc de la municipalité de Hay River. L'eau provient du Grand Lac des Esclaves et elle est pompée jusqu'à la collectivité qui se trouve à 3 milles au sud du poste de pompage. Pendant l'hiver, de décembre jusqu'à avril, il faut chauffer l'eau pour qu'elle ne gèle pas dans les conduites. Les frais de mazout s'élèvent actuellement à presque 100 000 \$ par an. L'installation du système de chauffage alimenté aux huiles usées décrit dans le présent rapport réduirait de façon sensible les frais annuels de chauffage.

Le système de chauffage alimenté aux huiles usées comprend entre autres: l'équipement servant au ramassage des huiles usées, le prétraitement, le stockage en vrac et la chaudière alimentée aux huiles usées. La documentation étudiée indique que la combustion d'huiles usées entraîne de graves problèmes techniques et d'exploitation. Ces problèmes sont liés à la contamination des huiles usées par des solides et par l'eau. Un traitement préalable pour enlever les solides et l'eau a été jugé nécessaire pour le système envisagé à Hay River afin de réduire le plus possible les effets de cette contamination. Le matériel choisi, comme le mieux adapté à la combustion des huiles usées, se compose d'une chaudière ignitubulaire et d'un brûleur à coupelle rotative.

L'étude évalue aussi l'émission de contaminants dangereux et les incidences éventuelles sur l'environnement. Pour diverses raisons, la teneur en contaminant dangereux des huiles usées ramassées à Hay River devrait être faible:

- Presque 40 % du volume total des hydrocarbures identifiés à Hay River se compose de combustibles contaminés avec de l'eau et avec d'autres substances ne présentant pas de danger.
- Les huiles pour moteur d'automobile ne représentent que 5 % du volume total des huiles usées disponibles. Le plomb est le principal contaminant et il ne se présente que dans le cas des essences contenant du plomb et des huiles de lubrification provenant de véhicules alimentés à l'essence au plomb. Toutes les autres huiles usées disponibles à Hay River proviendraient de moteurs diesel (c'est-à-dire de combustibles sans plomb).
- Hay River est un centre de transport et la plupart des huiles usées de la région y seraient disponibles. Il est moins probable que les huiles usées soient contaminées par des produits industriels (par exemple des solvants chlorés) à Hay River que dans des agglomérations plus grandes.

Le volume et les types d'huiles usées produites à Hay River ont été évalués par une enquête. Des échantillons d'huiles usées ont été obtenus et l'analyse des échantillons montre de bonnes propriétés à titre de combustible (sauf la

teneur en eau) et des teneurs faibles en contaminants dangereux.

En général, les émissions de plomb, de baryum et de chlorure d'hydrogène peuvent avoir des effets sensibles sur l'environnement, c'est-à-dire la qualité de l'air. Cependant, dans ce cas-ci, les émissions ne présenteraient pas de dangers graves pour l'environnement.

Selon les conclusions de ce rapport, les effets du système de combustion des huiles usées sur l'environnement (en utilisant les huiles usées de Hay River) seront de beaucoup en deçà des normes acceptables pour la santé fixées par les autorités.

Selon les estimations, le coût en capital du système de combustion des huiles usées va de 312 000 \$ à 327 100 \$. Le montant comprend 50 000 \$ pour un programme de contrôle des contaminants dangereux dans le combustible utilisé, dans les émissions et dans les résidus. La responsabilité de ce programme devrait revenir à Environnement Canada (Service de la protection de l'environnement).

Les frais d'exploitation et d'entretien du système de chauffage alimenté aux huiles usées sont évalués à 23 000 \$ par an. Ces frais sont additionnels aux frais d'exploitation et d'entretien de l'installation actuelle. Ces frais remplaceraient les frais actuels du combustible brûlé par l'installation actuelle, estimés à environ 96 250 \$ par an, dans l'hypothèse d'un prix du combustible égal à 35 cents le litre. Les économies s'élèveraient donc à 73 250 \$ par an et la période de récupération simple de l'investissement se situerait entre 3,6 et 3,8 ans.

Les chiffres susmentionnés partent de l'hypothèse selon laquelle la ville obtient l'huile usée gratuitement. S'il fallait payer les producteurs d'huiles usées, les frais d'exploitation et d'entretien augmenteraient. La valeur actuelle de l'huile usée à Hay River est évaluée à 9,8 cents le litre. S'il faut payer la totalité de l'huile usée à ce prix, les frais d'exploitation et d'entretien augmentent de 26 950 \$, donnant un total de 49 950 \$. Les économies annuelles sont alors ramenées à 46 300 \$ et la période de récupération simple passe à 5,7 ans.

Le système de chauffage aux huiles usées convient à d'autres localités septentrionales. Pine Point, Yellowknife et la région de Beaufort seraient des sites possibles d'implantation. On y produit des volumes suffisants d'huiles usées pour approvisionner en combustible des systèmes de chauffage alimentés aux huiles usées. La chaleur produite pourrait servir au chauffage des réseaux d'alimentation en eau (comme à Hay River), au chauffage d'immeubles publics ou de centres communautaires.

Du point de vue environnemental, le système de chauffage aux huiles usées qui est proposé, devrait constituer une amélioration importante quant à l'utilisation qui est faite des huiles usées, par rapport aux pratiques actuelles comme la combustion incontrôlée et l'utilisation des huiles comme abat-poussière.

L'étude a été menée pour la ville de Hay River par la firme Menacon Partnership à l'aide d'une contribution offerte par le Programme de démonstration dans les collectivités éloignées d'Énergie, Mines et Ressources Canada.

1.0 INTRODUCTION

The Town of Hay River currently spends almost \$100,000 annually to heat the domestic water supply. Municipal water is drawn from Great Slave Lake and heated during the winter months, December through April, to avoid frost and freeze-up in the transmission lines. The water is heated at the intake pumphouse, located on the south shore of the lake. A Cleaver Brooks 100 h.p. boiler is used at the pumphouse to meet the heating demand. Fuel costs for the 1984-85 season are estimated to be 35 cents/litre, or \$96,250 total.

This project is an assessment of the technical and economic feasibility of the installation of a second heating system at the intake pumphouse to heat the water supply. The second system would utilize waste oil as the fuel. There is a potential for significant savings in fuel costs for the heating system.

The objectives of this project are to: establish the availability of waste oil at Hay River, establish the technology of waste oil heating, and determine the economic viability of a suitable system for this heating application.

A survey was conducted to determine the types and sources of waste oil generated at Hay River (Chapter 2). The availability of the oil is assessed and current disposal practices noted. Samples of waste oil were obtained at Hay River. The samples were analyzed for fuel properties and contaminants (eg. lead, zinc, chlorine). The suitability of waste oil collected at Hay River as a fuel for the proposed heating system is discussed in Chapter 3.

A computer search was made to identify literature which addressed the concept of waste oil as a fuel and/or the associated technology. The practice of burning waste oil as a fuel was found to be common in the United States, but almost unheard of in Canada. In the literature reviewed, a tendency was noted that the negative aspects of waste oil combustion were stressed (emissions, operating problems). Only some of the literature reviewed identified combustion as a viable disposal method. In Chapter 4, the technology of burning waste oil is discussed. The proposed waste oil fired heating system is presented in Chapter 7.

Chapter 8 addresses the other components of the waste oil system: collection, pre-treatment and bulk fuel storage. Disposal of the residues from the pre-treatment system is also addressed.

Emissions and residues from a waste oil burning facility are discussed in chapters 5 and 6. The discussion is not specific to Hay River, but is an attempt to increase the awareness of environmental impact. Legislation is currently being introduced to regulate collection, transport, storage and disposal of many wastes, including waste oil and residues from waste oil reclaiming.

The capital costs and the operating and maintenance costs for a suitable facility are estimated in Chapter 9. The economic viability is assessed in Chapter 10. Net present value for baseline capital costs and operating and maintenance costs, is calculated. Factors which influence the viability of the project are examined. The benefits of the installation are presented.

In Chapter 11, alternate disposal practices are reviewed. Re-refining processes, road oiling and other combustion methods are included.

Recommendations for follow-up to this project are given in Chapter 12. A monitoring program for hazardous contaminants in collected waste oil, waste oil fuel, emissions and residues is described separately. The scope of the monitoring program is assumed to be developed with the guidance of the Environmental Protection Service.

Suitable locations for replication of the waste oil system described in this report are identified in Chapter 13.

A new burner and boiler, specifically selected for waste oil firing, represent only one component of the waste oil system. Also required are waste oil collection and pre-treatment systems, and bulk storage for the waste oil fuel. The existing boiler, which uses virgin fuel oil, would remain in place at the pumphouse as a standby unit.

This project is sponsored by is the Town of Hay River, with the support of Energy Mines & Resources Canada. Technical support has been received from the Environmental Protection Service (Environment Canada) in Edmonton, Ottawa and Yellowknife, and from the Waste Management Group of Alberta Environment.

2.0 WASTE OIL AT HAY RIVER

2.1 GENERAL SUMMARY

The total volume of waste oil generated at Hay River is estimated to be 400,000 litres per year. The waste oil is comprised of used oil (250,000 litres or 62.5%) and contaminated virgin fuels (150,000 litres or 37.5%). The terms "used oil" and "waste oil" are not used interchangeably in this report. Used oil is a component of the waste oil, and includes used lubricating oils, transmission fluids, hydraulic oils, gear lubricants, spent solvents and other non-fuel petroleum products no longer suited to their original use. Contaminated fuel includes spoiled virgin fuels, and "retain" and "slops" from the river transportation system. Drums returned to the bulk plant for container refund often contain small volumes of fuel and/or oil. These volumes are collected together and designated 'retain'. The term 'slops' is more general. Slops tanks are used to hold waste petroleum products of many types: contaminated fuels and used oils when no other storage is available, cleaning agents and washdown water, etc. Slops are characterized by extremely high water content.

Major "generators" of waste oil at Hay River are the two marine transport companies: Northern Transportation Co. Ltd. (NTCL) and Arctic Transportation Ltd. (ATL). The combined generated volume of these two companies represents 50% of the volume of waste oil generated at Hay River. Other sources of waste oil include Northland Utilities Ltd., automotive sales and service, heavy equipment and truck transport industries.

Of the 400,000 litres of waste oil generated annually, 350,000 litres were identified as potentially accessible by the Town. The Federal Ministry of Transport uses contaminated fuels for fire brigade practices at the airport, 36,000 litres/year have been assigned to meet this requirement. Other uses (or disposal methods) for waste oil identified at Hay River include road and

yard oiling, rerefining and burning with or without heat recovery. At least 75,000 litres of used oil were identified as used for road and dust suppression. Other volumes of used oil are transported to Edmonton where they are sold to Turbo Refinery for rerefining.

The fuel requirements for a waste oil fired heating system to replace the existing system at the intake pumphouse are estimated to be 275,000 litres/year. The minimum volume identified as being used on roads is 75,000 litres. The sum of these two volumes is 350,000 litres; ie. equal to the total volume identified as potentially accessible by the Town. It is clear that the Town will have to collect all volumes of waste oil available.

There will be competition for the use of waste oils, in addition to airport fire practice needs. Space heaters or 'waste oil furnaces' can be used for space heating using waste oil as a fuel. A unit in use at Kingland Ford has functioned satisfactorily. This will encourage other producers of waste oil to reclaim and utilize their own waste oil. At the moment few of the producers of waste oil generate a volume sufficient to support the purchase of a space heater. In the long term however, demand for waste oil is likely to increase. Hopefully, the Town will have 'first rights' to the waste oil.

At Pine Point, NWT, a significant volume (>475,000 litres) of waste oil is generated annually. The waste oil generated by Cominco Mines Ltd.(455,000 litres) is used for oiling of haul roads. The disposal practices for other volumes generated are not known, but are assumed to be road and yard oiling.

Currently, the Cominco mine utilizes all of their waste oil generated. Turbo Refinery at Edmonton has apparently offered the mine 38 cents/litre (FOB Pine Point) for used oils and has been refused by Cominco.

2.2 GENERATION OF WASTE OIL AT HAY RIVER

Potential sources of used oil, identified at Hay River, were: automotive (sales and service, rental, taxi fleet, etc.), transportation and shipping (road, marine, rail), government (GNWT Department of Highways, DIAND Forestry, Canadian Coast Guard), utility and heavy equipment (sales and service, operators). A survey was conducted at Hay River during October, 1984. Producers of waste oil were asked to assess their annual generation of used lubricating oils, solvents, contaminated fuel, slops and retain. All sources of waste oil were not contacted during the survey, and the volume generated for some sources was estimated on the basis of volumes generated by other similar sources. The generation of used oil by source is shown in Table 2.2-1.

The following comments apply to Table 2.2-1:

- 1) The volume of used oil generated by NTCL has been corrected on the basis of used oil returned to the Turbo Resources Ltd. Refinery (Edmonton) by NTCL. The volume of used oil generated by NTCL is recorded in this report as 45-68,000 litres.
- 2) The reported volumes of used oil generated by GNWT Department of Highways and the Canadian Coast Guard are thought to be extremely low. Attempts made to verify volumes were unsuccessful. In this report, volumes indicated by both sources are recorded as reported by the source, accompanied by a '+' sign.
- 3) Of the total volume of used oils estimated from the automotive sector, 30% (6,900 litres) was estimated without confirmation by source.
- 4) Of the total volume of used oils estimated from the truck transport industry, 40% (22,600 litres) was estimated without confirmation by source.
- 5) Of the total volume of retain (contaminated fuel) estimated from the bulk plants, 45% (7,000 litres) was not confirmed by source.
- 6) Irregular volumes of contaminated fuels generated by the bulk plants, DIAND Forestry, Canadian Coast Guard, etc. were not included in this survey.

Contact was not made with all potential producers of waste oil, such as construction companies, dry cleaners (used solvents), etc. It is estimated that 90% of waste oil generated at Hay River has been identified in Table 2.2-1. An adjustment factor for 90% was applied in the final determination of waste oils available.

More detailed background discussion on the estimation of waste oil available at the various sources indicated in Table 2.2-1 has been assembled in Appendix A.

TABLE 2.2-1: USED LUBE OILS AND CONTAMINATED FUELS AT HAY RIVER

	Used Lube Oil & Solvents (litres)	Contaminated Fuels (litres)
MARINE TRANSPORT		
NTCL	45-68000	90000
ATL	45000	27-32000
SUB TOTAL	90-113000	117-122000
SECONDARY SOURCES		
Northlands Utilities Ltd.	14-22700	
Freshwater Fish Marketing Corp.	900	
GNWT Dept. of Highways	10500+	
Town of Hay River	1400	
Canadian Coast Guard	700+	
HEAVY EQUIPMENT		
R. Angus	11000	
Fergusson Supply	7000	
SUB TOTAL	18000	
AUTOMOBILE SALES & SERVICE		
Hay River Motors	4500	
Kingland Ford	9000	
South MacKenzie (est)	2300	
Hay River Esso	2300	
Gulf (Hay River Motors) (est)	2300	
Other Auto.Services (est)	2300	
SUB TOTAL	22700	
TRUCKING		
Grimshaw Trucking (est)	6800	
Townsend Trucking	22700	
Stan Dean & Sons	8200	
CCL Transport (est)	4500	
Rowes (est)	6800	
Popes (est)	4500	
SUB TOTAL	53500	
BULK PLANTS		
Esso		9000
Other (est)		7000
SUB TOTAL		16000
TOTAL		
	211700-243400	133000-138000
for 90% Identification	235000-270000	150000-155000
Volume Available at Hay River	250000 litres	150000 litres

2.3 CURRENT DISPOSAL PRACTICES OF WASTE OIL

There are no municipal or territorial regulations which specifically address the disposal of waste oil at Hay River. The Federal Department of Fisheries and Oceans prohibits dumping of waste oil into public waters. Accordingly, yard and road oiling on Vale Island has been banned. A town bylaw exists prohibiting the dumping of "waste of any kind on a town street" (G.19.10.6). However, there is some feeling that waste oil is not included in this restriction, as yard and road oiling is a common practice.

The Federal Department of Fisheries at Hay River was contacted for comment on waste oil disposal practices. They indicated they were aware of 'dumping' of oil on roads and in construction yards, but felt the oil would leach out long before reaching the water. Despite this consolation, road oiling is discouraged except where necessary for human safety (dust suppression).

Many producers of used oil contacted were vague about their disposal practices. It is likely that far more oil is used for yard and road oiling than was indicated during the survey.

Disposal practices of the sources surveyed are given in Table 2.3-1. Tables 2.3-2 through 2.3-4, break down the volumes by disposal method reported. All of the contaminated fuel appears to be used for secondary purposes: fire training, brush burning. When surveyed, NTCL indicated there was no demand for diesel slops but did not define their disposal method.

In Table 2.3-1, indication is made if the firm is likely to face a cost for waste oil disposal. Costs can be external to the firm (eg. payment to a second business) or internalized (firm hauls to dump for disposal). If the waste oil producing firm uses the oil for a secondary purpose (road and yard oiling) or gives the waste away, the cost of disposal is considered as nil.

The Federal Ministry of Transport (MOT) uses the services of Hay River Disposal for pickup of contaminated fuels (from source) and delivery to the airport. Cost of this service was given as \$40.00 per 1,700 gallons. The same cost can be assumed for used oil disposal.

NTCL indicated that used oil is returned to the Turbo Resources Refinery in Edmonton. Remple Trucking charges a backhaul rate 3.8 cents/litre, Hay River to Edmonton.

TABLE 2.3-1: DISPOSAL OF WASTE OIL AT HAY RIVER

Source	Type of Waste	Volume Litres	Cost for Disposal	Disposal Method
NTCL	Cont.Fuel Used Oil	90,000 45-68,000	No Yes	MOT, Town (burning) Shipped to Turbo Ref., Edmonton
ATL	Cont.Fuel Used Oil	27-32,000 45,000	No No	MOT, Town (burning) Collected by Bassett Trucking
Northlands Utilities Ltd.	Used Oil	14-22,700	No	Collected by Bassett Trucking
Freshwater Fish Marketing Corporation	Used Oil	900	No	Dust control in yard
GNWT Dept. of Highways	Used Oil	10,500+	No Yes	Dust control on roads Haul to dump during winter
Town of Hay River	Used Oil	1,400	Yes No	Haul to dump for burning Dust control on roads
R. Angus	Used Oil	11,000	Yes	Sewer truck removal
Fergusson Supply	Used Oil	7,000	No	Dust control in yard
Hay River Motors	Used Oil	4,500	No	Given at request for lane & yard oiling
Kingland Ford	Used Oil	9,000	No	Fuel for space heater
Hay River Esso	Used Oil	2,300	Yes No	Hauled to dump If used by Kingland Ford
Townsend Trucking	Used Oil	22,700	Yes	Sewer Truck Removal
Stan Dean & Sons	Used Oil	8,200	No	Dust control in yard
Coast Guard	Used Oil	700+	Yes	Hauled to dump
Esso Bulk Plant	Retain	9,000	Yes	Shipment to Edmonton for disposal

TABLE 2-3.2: WASTE OIL VOLUMES DESIGNATED AS BEING BURNED
AT DUMP

Town of Hay River	1,400
R. Angus	11,000
Hay River Esso	2,300
Townsend Trucking	22,700
Coast Guard	<u>700+</u>
Total	38,000+ litres

TABLE 2-3.3: WASTE OIL VOLUMES BEING USED FOR DUST CONTROL

Freshwater Fish Marketing Corp.	900 litres
GNWT Department of Highways	10,500+
Fergusson Supply	7,000
Hay River Motors	4,500
Stan Dean & Sons	<u>9,000</u>
Total	31,900 litres

TABLE 2-3.4: WASTE OIL VOLUMES DESIGNATED AS BEING RETURNED
TO EDMONTON FOR REREFINING

NTCL	45- 68,000 litres
ATL (by Bassett)	45,000
Northlands Utilities Ltd. (by Bassett)	<u>14- 22,700</u>
Total	104-135,700 litres

Table 2-3.2

A total of 38,100 litres of oil was claimed to be disposed of by burning at the town dump. An attempt was made to establish the actual total volumes being burned at the dump. As noted earlier, it was discovered that volumes designated as being burned at the dump were in fact collected by the town for road oiling.

If the collection truck recovers only waste oil (no sewage), the volume is deposited in a 15,000 gallon tank located in the town yard. The total volume of oil available to the town in this manner was estimated to be 60-90,000 litres per year. The oil was used for dust control on the lagoon road, the pumphouse road and the backroads of the industrial park.

Sewage which is contaminated with oil is dumped into the clay pit at the town dump and burned perhaps twice a year. Volumes of oil burned were estimated to be 20-30,000 litres. In November, 1984, a gravel seam was discovered beneath the claypit. Continued usage of the pit for waste oil disposal is questionable due to possible leakage to the water system.

Table 2.2-3

A total of 31,900 litres was claimed to be used for dust control in yards and on roads by waste oil producers. Adding the volumes applied by the town (60-90,000 litres) a minimum of 95,000 litres is thought to be applied as a dust suppressant at Hay River.

Table 2.2-4

The total volumes of oil designated as returned to Edmonton for re-refining is 104,000 to 135,700 litres. NTCL has shipped used oil to Edmonton using Remple Trucking. ATL and Northland Utilities Ltd. have used the services of Bassett Trucking.

Bassett Trucking

Bassett Trucking and Piloting has collected used lubricating oil from producers at Hay River. A 100 bbl (16,000 litres) crude oil tank truck with a vacuum collection system is used.

During the summer and fall of 1984, Bassett collected two tank loads of used lubricating oil which was sold to the Turbo Refinery at Edmonton. Producers of the oil (Northlands Utilities and ATL) were pleased with the service as it eliminated disposal problems. ATL was especially pleased because drums of used oil were emptied while still on the barge. Removal of empty drums from the barge was a much easier task and the drums (which carry \$25.00 deposit) were less damaged.

2.4 AVAILABILITY OF WASTE OIL AT HAY RIVER

2.4.1 Summary

The availability of waste oil at Hay River is determined by two factors:

- 1) value assigned to waste oil by the owner, and
- 2) value assigned by potential users of the waste oil.

Very few known producers of waste oil assigned a value to waste oil. Road and yard oiling was the only identified use for used oil. The survey indicated that in most cases yard oiling was practised primarily as a disposal method, not for benefits realized. There was no evidence that the oil was being properly applied as a dust suppressant but was simply spread over the yard.

The total volume of waste oil generated at Hay River is estimated to be 400,000 litres: 250,000 litres of lube oil and 150,000 litres of contaminated fuel. A volume of 350,000 litres waste oil is potentially accessible by the town for the burning facility. The balance is required by MOT for fire suppression training. Approximately 275,000 litres/year of waste oil is required to supply the fuel requirements of the waste oil fired heating system.

2.4.2 Contaminated Fuels

The volume of contaminated fuel (150,000 litres) is a significant portion (40%) of the wastes accessible by the town. The producers have no use for the fuel but there is competition among secondary users:

- Contaminated fuels are used by the Ministry of Transport for fire-fighting training sessions at the airport. Excess volumes made available to MOT are shipped to airports at other locations (Yellowknife, Fort Smith).

- The town has used contaminated fuels for lagoon and brush burning.
- Kingland Ford has collected contaminated fuel for use in a space heater in their garage.

The major sources of contaminated fuels have indicated that the volumes would be made available to the town. The sources would likely continue to supply the requirements of MOT since a benefit is gained - MOT have supplied fire training to NTCL and would likely do the same for ATL.

Ministry of Transport

Federal regulations require that MOT fire fighters attend 1 practice session per month. The size of fire is usually 1000 - 2200 litres of fuel.

Fire fighters are assigned an annual volume of fuel:

- experienced (1 year or more) - 4,500 litres
- novice (less than 1 year) - 9,000 litres

There are 6 MOT firefighters at Hay River: 1 fire chief, 1 fireman, 4 auxilliary. A minimum of 27,000 litres (6 experienced fire fighters) or a maximum of 45,000 litres (2 experienced, 4 novice fire fighters) is required. 27,000 litres is sufficient for one large (2,200 litre) fire per month, 45,000 litres is sufficient for twenty large fires, almost two fires per month. In determining the volume waste oil accessible by the town, 50,000 litres has been assigned to fulfil MOT requirements.

2.4.3 Used Oil

When surveyed, many producers of used oil indicated that the volumes would be made available to the town. Some producers (GNWT Highways, Kingland Ford) indicated they had their own requirements for some or all of their used oil.

During the survey, it was suggested several times that all of the proposed facility's fuel requirements could be met by Cominco Mines at Pine Point and/or NTCL. However, at this time, used oil generated by Cominco is not considered readily accessible by the Town (Section 2.6.1).

The total volume of waste oil generated by NTCL is 135-158,000 litres. The supply of waste oil from NTCL is not secure in volume or accessibility. Reclaiming of contaminated fuels is a priority for NTCL. The bulk lubricating oil system planned at NTCL in (1985) will also affect the accessibility of used oil since the oil will be more easily collected to return for re-refining.

ATL is the second major source of waste oils at Hay River with a total generation of 72-77,000 litres of waste oil.

It is apparent that even if the total generation of waste oil by NTCL and ATL were accessible by the Town, other volumes would be required. Many of the smaller sources of waste oil are willing to give the waste to the Town. These smaller sources must be accessed to supply the proposed facility with 100% of fuel requirements.

2.4.4 Costs and Conditions of Securing Waste Oil

Most producers of waste oil indicated that waste oil would be given freely to the Town if the Town or the Town's agent collected the waste oil at the source. Exceptions are noted below.

NTCL: NTCL have indicated that lube oil would not necessarily be given freely to the Town. A negotiated price for the used oil may have to be paid to secure the used oil from NTCL, an actual value has not been indicated. NTCL did not assign a value to contaminated fuel and slops. They did suggest that a legal agreement covering supply (not guaranteed), collection etc., may be required.

NTCL has been sold recently. The new owners have not been contacted.

R. Angus: The manager of R. Angus indicated no interest in reclaiming oil for any purpose. Waste oil is currently disposed of with the septic removal. If containers were supplied and no special handling by mechanics was required, the waste oil would be made available to the Town.

Stan Dean & Sons: Waste oil storage facilities were apparently not in place at Stan Dean's. Containers may have to be provided.

Payment for Waste Oil

With the exception of NTCL, none of the sources surveyed indicated a monetary value for the waste. It is conceivable that if NTCL receives payment for used oil, other generators of used oil may request payment.

Payment for used oil would be an involved process. High water

contamination of oil is common, and payment would have to include a water allowance and/or penalty. Waste oil would then have to be sampled at time of collection and analysis for water content be done (at Hay River or elsewhere). Payment would be on the basis of fuel collected. A penalty for high water content is required as the Town will be ultimately responsible for disposal of the oily waste water, in an environmentally safe manner.

Used lubricating oil has a value of 13 cents/litre at the Turbo Refinery in Edmonton. Transportation costs are 3.4 cents/ litre from Hay River to Edmonton (backhaul rate). The value of waste oil can be assessed as 10 cents/ litre at Hay River. The Turbo Refinery has a 10% water allowance, and oils with higher water content are assessed a penalty.

Payment for contaminated fuels has not been indicated by any producers.

Collection Costs

MOT indicated that Hay River Disposal charged \$40.00 for pick up and delivery of 1700 gallons (8,000 litres) of contaminated fuel. If water contamination is assumed to be 40%, then 4,800 litres of fuel are collected; and a collection cost of $\$40.00/4,800 = 0.83$ cents/litre is estimated. The cost per litre would be lower with a lower water contamination.

The above cost is based on one pick up location. Costs would increase for pick up at a number of locations where smaller volumes are available. Estimated cost for pick up of the same volume (8,000 litres) at 3-4 separate locations is \$60.00, or 1.25 cents/litre (40% water contamination).

Water contamination in the fuel will affect collection cost per litre. In Table 2.4-1, this cost is given for different water concentrations.

TABLE 2.4-1 COLLECTION COST

% H ₂ O	Volume Waste Oil Collected	Collection Cost based on \$60/collected load (8,000 litres)
40	4,800 litres	1.25 cents/litre
30	5,600	1.07
20	6,400	0.94
10	7,200	0.83
<5	7,600	0.79

Collection costs will also be affected by the size of the collection vehicle. Much of the collection time is incurred by driving to and from the pumphouse where collected waste oil is stored. Obviously, a large truck (eg. 100 bbl) would make 1/2 the number of trips needed for a small truck (50 bbl). It is estimated that use of a small vehicle would increase collection costs by approximately 1/3.

2.5 BACKLOG INVENTORY OF WASTE OIL ON HAND AT HAY RIVER

No large stockpiles of waste oil have been identified at Hay River. Most producers of waste oil have limited storage facilities and tend to dispose of the waste oil when storage capacity is exceeded. Used lubricating oil can be stored indefinitely in closed drums, as the heat and lubricating quality of the oil is not lost. Extended storage of fuels will result in significant losses through vaporization and may present a safety hazard.

The storage capacities of firms surveyed are given in Table 2.5-1. Smaller producers generally have storage less than the annual produced amount and dispose of waste more often than once a year.

The Town of Hay River has a 60,000 litre storage tank which is used to receive oil. The oil is used for road oiling. No waste oil was currently on hand. A separate volume of 20,000 litres waste oil was indicated as being received from NTCL in drums and was on hand.

Kingland Ford had collected 18-20,000 litres of waste oil to be burned in a waste oil heater in the garage (October, 1984). Volumes of used lube oil generated over the winter by Kingland Ford will also be burned in the heater.

NTCL have indicated the possibility that 10,000 litres of naptha (minus evaporation losses through winter) and 10,000 litres of turbo jet fuel (if it cannot be salvaged) may be available at spring break-up (May, 1985). Mention was made of 45,000 litres of contaminated aviation gas which NTCL planned to try to salvage. All of the above volumes may be available to the Town for the proposed facility.

With the exception of ATL and NTCL, waste oil generation rates

were deemed to be fairly constant throughout the year.

TABLE 2.5-1: WASTE OIL STORAGE FACILITIES AT HAY RIVER

Source	Storage Capacity (litres)	Generation (litres/year)	Comments
TANK STORAGE			
NTCL - Oil - 2 tanks	45,000	45-68,000	Summer generation Peak Spring (larger storage volume req'd for high water con- mination)
Slops - 4 tanks	190,000	90,000	
Fergusson Supply	3,400	7,000	
Hay River Motors	2,300+drums	4,500	
Northland Utilities		14-22,700	Peak Spring & Fall Generation
GNWT Dept. of Highways	22,700	14,000	
DRUM STORAGE			
Canadian Coast Guard		700+	
Canadian National Railways (Peace River Yard)		14,000	
Town of Hay River (have a 15,000 gal. storage)		1,400	
Stan Dean & Sons		9,000	
Freshwater Fish Marketing Corp.		900	
Eso Bulk Plant		9,000	
ATL - Lube Oil		45,000	Summer Generation Peak Fall
- Slops		27-32,000	
NO STORAGE INDICATED			
R. Angus		11,000	
Townsend Trucking		22,700	

2.6 VOLUMES OF WASTE OIL NEAR HAY RIVER

2.6.1 Pine Point

Cominco Mines Ltd. operate an open pit lead-zinc mine at Pine Point, NWT. A large number of heavy equipment are used in the operation and a large volume of used oil is generated.

Volumes of non-fuel petroleum based products purchased by Cominco are given in Table 2.6-1.

TABLE 2.6-1: PURCHASED NON-FUEL PETROLEUM PRODUCTS
COMINCO PINE POINT

Product	Gal./mo.	Annual Generation (litres)	Recovery Rate	Volume Waste Oil (litres)
S + 10	7,000	380,000	50% ^a	190,000
S + 30	3,100	170,000	50% ^a	85,000
HV1-22	900	50,000	80% ^b	40,000
GL 80W90	1,300	70,000	80% ^b	55,000
Varsol	1,000	55,000	80% ^b	45,000
Glycol	900	50,000	80% ^b	40,000
TOTAL				455,000

^a assessed as equivalent to recovery rate for farming sector
Ref. 2

^b assumed recovery rate, including evaporation losses

Recovery rates of 50% for lube oil, 80% for solvents and lubricants have been assumed for the mining industry, indicating a total volume of 455,000 litres waste produced by Cominco Pine Point.

Cominco uses 100% of the waste oil generated for oiling haul roads. This is an essential practice as the haul roads are extremely wide (150 feet) and dust on the roads is a hazard to human safety.

Turbo Resources at Edmonton have apparently offered the mine 38 cents/gallon (8.3 cents/litre) FOB Pine Point for used lube oils. The offer has not been accepted, indicating the value of used oil to Cominco. At the moment, if there was an excess of used oil available at Pine Point they would likely sell the oil to Turbo.

The GNWT Motor Vehicles Branch indicates 791 cars and trucks are registered at Pine Point: A volume of 7,000 litres used oil is estimated to be generated by the automobile sector. NCPC (Northern Canadian Power Commission) generation of used oil at the Talston Hydro Station is estimated to be 16,400 litres (Table 13.2-2). The total volume of waste oil produced at Pine Point is estimated to be 478,400 litres.

2.6.2 Enterprise

Enterprise is a small community (population 40) located immediately south of Hay River. The community is located at the junction of the MacKenzie and Yellowknife highways, and relies heavily on automotive and transport truck service industries.

It is especially difficult to evaluate the used oil supply at Enterprise. The GNWT Motor Vehicle Branch indicates almost 300 light vehicles (cars, trucks, etc.), 361 truck tractors and 417 truck trailers are registered at Enterprise. Highway transport vehicles often register at Enterprise although the trucks are serviced in Edmonton and elsewhere. The GNWT Department of Highways runs a division yard at Enterprise. Attempts to determine the amount of used oil generated were unsuccessful.

Current disposal methods for used oils at Enterprise are assumed to be road and yard oiling.

Actual volumes of waste oil generated at Enterprise per year are expected to be small.

3.0 CHARACTERIZATION OF WASTE OIL AS A FUEL

3.1 APPLICATIONS

Of the estimated 4 billion litres of waste oil generated annually in the United States, it is estimated that 50% is burned for heat recovery. Waste oil is used as a fuel component in approximately 60,000 commercial and industrial facilities in the United States (Ref 1). These facilities range from 30 kilowatt space heaters (0.1×10^6 BTU/hr) to 0.5 megawatt power plants (1500×10^6 BTU/hr.). With the exception of space heaters, few installations burning 100% waste oil were identified in literature. The more common practice is to blend the waste oil with virgin fuel (No. 2 distillate, No. 6 residual, or coal) in fractions of 5-25%.

Space heaters are usually used to burn waste oil at the generation source, eg. automobile service station and repair shops, heavy equipment shops. The oil is not usually treated for removal of contaminants and there is no pollution control.

With the proper pre-treatment, used oil from diesel engines can be burned in diesel engines. The oil is mixed with the diesel fuel, causing contaminants to precipitate out as a metallic salt. The fuel blend is filtered for removal of contaminants, then mixed with the main fuel stream. Fractions of 5% used oil are being used successfully in several major trucking fleets.

Waste oil is also burned for heat recovery in asphalt plants and cement kilns. Cement kilns are considered an environmentally safe disposal practice as lead, PCB's and other contaminants in the waste oil are trapped in the cement clinker and therefore no longer considered hazardous.

The previously described applications account for very little of the waste oil burned in the United States. The bulk of the burned oil is burned in a blend in commercial and industrial boilers.

There were no specific applications of waste oil burning identified in Canada. There is apparently some type of facility in the Maritimes which burns used lubricating oils. There are reportedly severe operational problems associated with the facility, specifically high ash formation and burner nozzle clogging.

A train used at Fort Edmonton Historic Park at Edmonton, Alberta has reportedly used lube oils for fuel. The suppliers were contacted to verify the fuel type. The first supplier indicated that fuel supplied to Fort Edmonton was invoiced as 'Waste Bunker Oil', and was in fact Waste Bunker C, 'lube oil of a type'. The second supplier invoiced the fuel as 'Used Petroleum Products'. Crude oil is mixed into the fuel to produce black smoke (considered picturesque at an historical park). This supplier has supplied the same fuel for trains at two other historical parks in British Columbia.

3.2 GENERIC PROPERTIES OF FUEL

A brief description of fuel properties is given below:

Heat value of oil is a function of density (where density or specific gravity is measured by the petroleum industry in American Petroleum Institute (API) degrees.) Heat value can be measured in BTU/gallon or joule/litre, (increases with decreasing density) or in BTU/lb (decreases with decreasing density). High water content in a fuel reduces the heat value of a fuel as heat is required to evaporate the water.

Viscosity is a measure of resistance to flow and reflects the handling characteristics of the fuel. A low viscosity (measured in centistokes or Saybolt Universal Seconds, SUS) is desirable, to facilitate pumping and atomization.

Pour point of a fuel is the "freezing" point or the lowest temperature at which the fuel will flow.

Flashpoint is an indication of the maximum temperature at which the fuel can be handled without serious fire hazards. The distinction between flammable and combustible is made on the basis of flashpoint.

combustible: Flashpoint $> 37.8^{\circ}\text{C}$, but $< 93.3^{\circ}\text{C}$

flammable: Flashpoint $< 37.8^{\circ}\text{C}$

Bottom solids and water (BS&W) is a measure of contamination of fuel. Appreciable amounts of water and sediments in a fuel oil tend to cause fouling of the facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and/or filter screens or burner parts, resulting in obstruction of flow of oil from tank to the burner. Water in distillable fuels may cause corrosion of tanks and equipment and it may cause emulsions in residual fuels.

Ash is the non-combustible material in fuels and is the residue remaining after thorough combustion is complete.

3.3 WASTE OIL AS A FUEL

Waste oil is a mixture of many types of oil and contaminants. Fuel properties are difficult to assign because of the variance in types of oil, sources and contamination. Table 3.3-1 shows the ranges of properties of virgin fuel oils and used oils.

Most of the data in the literature refers to used automotive oils. Concentrations of lead and other trace metals are generally higher in automotive oils than industrial oils. Because of the potential environmental impact from road oiling or burning of used automotive oils, they are more likely to be sampled and analysed for contaminants. Automotive oils tend to be generated in smaller volumes than industrial oils, and therefore are more likely to find their way into a collection system. Used industrial oils are usually reclaimed for a specified purpose (re-refining, fuel, secondary lubrication) and are not as likely to be sampled or analysed for public safety.

The application of the data in Table 3.3-1 to waste oil collected at Hay River is questionable. The introduction of contaminated fuels into the waste oil collection system affects some fuel properties significantly, specifically BS&W, viscosity, flashpoint and pour point. As well, the incidence of automotive oil (from gasoline engines) is very low in relation to incidence of lubricating oils from diesel engines found in the truck transport, marine and utility sectors. Metals contamination, especially lead, will be significantly different in the diesel engine oils and gasoline engine oils.

The heat content of waste oil is affected by BS&W content. For waste oil with the water removed, the heat value is comparable to No. 2 and No. 6 fuel oils (18,500 BTU/lb or 43.0 M Joules/kg). The presence of water can downgrade the heat value seriously, and will also create serious operational problems. The addition of

TABLE 3.3-1: PROPERTIES OF VIRGIN FUEL OIL (NO. 2 DISTILLATE AND NO. 6 RESIDUAL) AND USED OIL (AUTOMOTIVE CRANKCASE DRAININGS)

Property (a)	Composite Range Values		
	No. 2 Distillate	No. 6 Residual	Used Oil, Crankcase Drainings
Gravity, deg API at 60°F	30.2 to 43.3	0.3 to 26.0	20.0 to 27.9
Specific Gravity	0.800 to 0.875	0.898 to 1.022	0.887 to 0.934
Density, lb./gal	6.68 to 7.30	7.5 to 8.5	7.4 to 7.78
Viscosity, SUS at 122°F	-	24 to 350	-
Viscosity, SUS at 100°F	32 to 40	-	87 to 837
Viscosity, Centistokes	1.8 to 4.1	7 to 750	17.3 to 180.6
Pour Point, °F	(-50) to 25	(-10) to 95	<(-40) to (-30)
Flash Point, °F	126 to 204	150 to 270	170 to 415
Heating Value, Btu/gal	130,900 to 141,800	146,100 to (>157,700)	105,555 to 143,360
Heating Value, Btu/lb	18,145 to 19,895	17,410 to (>20,480)	13,571 to 19,300
Neutralization Number, mg KOH/gm	-	-	4.0 to 14.3
Bottom Solids and Water, vol %	0.00 to (<0.1)	0.00 to 2.00	0.1 to 22.0
Sulphur, wt%	0.02 to 0.59	0.3 to 4.0	0.21 to 0.65
Ash, wt %	0.00 to 0.005	0.00 to 0.50	0.03 to 3.78
Silicon, ppm	-	8.2 to 164.0	10 to 875
Calcium, ppm	-	0.7 to 95.0	700 to 3,000
Sodium, ppm	-	1 to 480	16 to 300
Iron, ppm	-	10.5 to 230.0	50 to 2,000
Magnesium, ppm	-	0.4 to 27.9	10 to 1,108
Lead, ppm	-	1.7 to 4.1	800 to 11,200
Vanadium, ppm	-	1 to 380	3 to 39
Copper, ppm	-	0.5	5 to 348
Barium, ppm	-	-	10 to 2,000
Chromium, ppm	-	13.7	8 to 50
Nickel, ppm	-	3 to 118	3 to 80
Aluminum, ppm	-	0.5 to 219	10 to 800
Silver, ppm	-	0.3	1
Titanium, ppm	-	5.5	5 to 30
Molybdenum, ppm	-	2.3	2 to 3
Zinc, ppm	-	-	300 to 3,000

TABLE 3.3-1 (continued)

Property (a)	Composite Range Values		
	No. 2 Distillate	No. 6 Residual	Used Oil, Crankcase Drainings
Phosphorus, ppm	-	-	500 to 2,000
Tin, ppm	-	-	5 to 112
Beryllium, ppm	-	-	6
Manganese, ppm	-	-	5 to 10
Cadmium, ppm	-	-	4
Strontium, ppm	-	-	10 to 30
Boron, ppm	-	-	3 to 20

(a) ppm (as the element) = 0.0001 wt %.

1 lb/gal = .12 kg/litre

$0_F = 0_C(9/5) + 32$

1 BTU/gal = 279 joules/litre

1 BTU/lb = 2325 joules/kg

Staybolt Furol Seconds (SFS) = Centistokes x .4717

Staybolt Universal Seconds (SUS) = Centistokes x 4.6347

Specific gravity in relation to water = 141.5/(131.5 + deg.API)

assembled from references 1,3,4,9,21

contaminated fuels to the oil will not affect heat content significantly as long as water is removed from the fuel.

The viscosity of waste oil will reflect the sources and types of the used oils collected. Automotive used lubricating oils (SAE 30) are less viscous than heavy equipment oils (SAE 40 or 50). The presence of contaminated fuels will reduce the viscosity of waste oil collected at Hay River. Used oils are typically more viscous than No. 2 fuel oil, but less viscous than No. 6 fuel oil.

Pour point depressants are added to lubricating oils to ensure their effectiveness at low temperatures. The pour point of used oil is generally less than that of No. 2 or No. 6 oils. The presence of contaminated fuel will decrease the pour point of waste oil.

The flash point of uncontaminated used oil is higher than No. 2 and No. 6 fuel oils, indicating no special handling requirements. A low flash point is an indication of volatile contaminants (solvents, fuels). The deliberate addition of contaminated fuels will also lower the flashpoint. Special handling techniques (eg. segregation of extremely volatile components) may be required.

BS&W is another indication of contamination. Without pre-treatment, the BS&W of used oil can be even higher than indicated in Table 3.3-1. Values of 30-40% BS&W are not uncommon for used oil. Values for contaminated fuels and slops can be as high as 80%.

The most immediate effect of BS&W is to decrease the heat value of the fuel as heat is required to evaporate the water. A wide range of operating and maintenance problems are also due to BS&W content.

Ash content of waste oil is appreciably higher than No. 2 and No. 6 fuel oils. Higher maintenance costs for the oil burner are the result. The higher ash content is due to contamination by solids (dirt, sand, etc.) and soluble metals in the waste oil.

3.4 CONTAMINANTS IN WASTE OIL

3.4.1 General

Contaminants in waste oil may originate from usage or from mixing with other wastes. The original additives to the lubricating oil stock may also be considered contaminants when burning. With the exception of lead, most of the major contaminants arise from poor management of wastes. These include water, solids, solvents, PCB's (if present) and fuel. Lead occurs as a component of fuel contamination due to piston blowby from engines (automobile and aircraft) using leaded gasoline.

Contamination often occurs when one tank is used to receive and store all liquid wastes: used lube oil, transmission oils, hydraulic fluids, solvents, greases, wash down water. Further contamination occurs during collection, since vacuum trucks are often also used for septic tank clean out, waste chemicals or contaminated fuels transport, etc. Residues from these fluids and others will inevitably get mixed in with the oil.

There are no fixed or typical values for contaminants in waste oil. Segregation of wastes will have the most immediate effect on quality of used oil. This practice is not always reasonable since a separate disposal system(s) for the other waste(s) would be required.

3.4.2 Solids and Water

Water is the major contaminant of waste oil (slops and retain from the barges can be 80% water and higher.) Natural settling and decanting of the waste oil will result in fuel with 5-15% water content.

Solids in waste oil include dirt, sand, sediment, atmospheric dust, rust, soot, lead from piston blowby, wear metals, metal

finer and filings, etc. Over time, coarse solids will settle in a sludge at the bottom of the holding tank. Finer solids will remain in suspension, and create problems of burner nozzle clogging and erosion of pumps and burners. If not removed from the fuel, solids will contribute to ash and particulate emissions.

The majority of problems associated with burning waste oil as a fuel are related to operating and maintenance, and can be attributed directly to the presence of solids and water. Effects of water and solids contamination are:

- 1) reduced heat value (BTU/lb)
- 2) burner flame out
- 3) freezing in the fuel line
- 4) filter and strainer clogging
- 5) excessive wear of pumps
- 6) erosion of burner nozzle and tip
- 7) corrosion and fouling of heat transfer surfaces
- 8) seal damage

These problems can be avoided or minimized in various ways: use of wide orifice nozzles with steam atomizing, redesign of strainers and fuel lines, pretreatment of the fuel for water and solids removal.

Pre-treatment may consist of settling and decanting or may consist of more sophisticated techniques including filtering, heating, or centrifugation. Settling alone will not improve a significantly low BS&W (eg. <10%) fuel.

Detergents and dispersants are part of the additive package in lubricating oils. These serve to keep sludge, carbon, water and other products of usage in suspension in the oil. These products of usage are precursors to deposit formation. The additive forms an envelope around the contaminant, and maintains the suspension (i.e. maintains lubricating quality of the oil). Effective

removal of solids and water will include the breakdown of the additives.

3.4.2 Metals

Metals are introduced to waste oil as a product of use or as an original additive in the lubricating oil or fuel. Table 3.3-1 shows the ranges of metals concentrations in used automotive oils.

The metals may exist as particles or solubles in the oil. Additive components are soluble. Metal fines and filings are particulates and may be held in suspension (eg. lead from piston blowby). Metal fines and filings are the result of machine or engine wear, and may include aluminum, copper, iron, lead, silicon and tin. Additive compounds may include barium, calcium, magnesium, sodium, phosphorus and zinc. Cadmium and chromium may be original additives to the oil or may result from engine wear. Boron is a fuel component and occurs in used oil by blow-by and fuel contamination. The source of arsenic in used lubricating oils has not been determined.

Lead, in addition to being a wear metal, will occur in lube oil through piston blow-by in gasoline leaded engines and fuel contamination of the lube oil. Diesel fuel does not contain the organic lead antiknock compounds (tetraethyl lead, TEL, and tetramethyl lead, TML). Therefore, lead is not a contaminant of diesel engine lubricating oils. Lead can also be a component of some anti-wear and extreme pressure additives.

The effect of metal contaminants in waste oil is well known. All metals will contribute to ash formation and particulate emissions. At the high temperatures in the flame zone, lead, zinc and other trace metals undergo secondary reactions and form volatile species. These species will subsequently condense and

occur in the flue gas as sub micron sized particles.

Calcium and phosphorus do not volatilize during combustion, they melt and fuse with the oil droplets. When the hydrocarbons have been consumed, the ash skeleton remains.

Pretreatment of waste oil for solids and water removal will remove metals which exist as particles and those which are water soluble. Remaining metals are oil soluble.

Some metal contaminants which are soluble in oil may be precipitated out as metallic salts in the presence of fuel. This technique is practiced in the truck transport industry for removal of contaminants in used diesel lubricating oil. The oil fuel mixture is filtered for removal of the metallic salts prior to use of the oil.

3.4.3 Chlorinated Organics

Chlorinated solvents (eg. degreasing compounds) are considered a special group of contaminants. They are not fuel or oil additives, but are introduced through poor management by collectors and generators.

Five potentially hazardous chlorinated solvents are commonly found in waste oil:

- dichlorodifluoromethane
- trichlorotrifluoroethane
- 1,1,1 - trichloroethane
- trichloroethylene
- tetrachloroethylene

The level of contamination of waste oil by chlorinated solvents, varies from less than 100 to several thousand ppm.

An indication of chlorinated solvent contamination in an oil sample is the measurement of total chlorine. Chlorine may be present in other forms (eg. inorganic salt), but the analysis will indicate the presence of potentially hazardous chlorinated solvents. Typical chlorine ranges are 1,000-5,000 ppm.

Contamination levels found in a set of 400 samples of waste oil are summarized in Table 3.8-8. (Ref. 1)

3.4.4 Other Organics Constituents

This group includes non-halide solvents, glycol (antifreeze) and fuels (gasoline, diesel from fuel leakage, etc.) These fluids are readily combustible and emissions are not of environmental concern. Also included are aromatic solvents, polynuclear aromatic hydrocarbons (PNA's or PAH's) and polychlorinated biphenyls (PCB's).

Aromatic solvents are inherent to the lube oil base stock and are acquired during the use of this oil and through mixing of waste solvents. Typical concentrations of aromatic solvents are:

toluene, xylene	500-5000 ppm
benzene	100-300 ppm

PNA's are complex hydrocarbons which have been linked to cancer. They are found in all heavy fossil fuels. There is a tendency for PNA's to concentrate in used automotive oils, as a consequence of incomplete combustion in the engine. The concentrations of PNA's in waste oil can range up to several hundred ppm. Typical ranges are:

benzo(a)anthracene	10-50 ppm
benzo(a)pyrene	5-20 ppm
napthalene	110-1,400 ppm

The concentration of PNA's in waste oil is critical as they are not destroyed in normal burning. Temperatures of 1400°C to 1650°F and adequate residence time are required to consume PNA's.

The possibility of PCB's occurring as a contaminant in the waste oil collection system at Hay River is very remote. The federal government maintains and monitors an inventory of askerols or pure PCB's and no inventory has been identified in the Hay River area. Medium grade PCB fluid contamination can result from poor waste management, eg. temporary storage of PCB's, containers being reused. The local power company, Northlands Utilities (NWT) Ltd., have indicated there is no PCB equipment in the area and there has not been for several years. Previously, 1 small capacitor did use PCB's. The unit was not serviced at Hay River so contamination is unlikely to have occurred.

Until the early 1970's small amounts of PCB's were added to some automobile transmission fluids for enhanced swelling of rubber seals. PCB contamination could occur in automotive used oil. This is unlikely, however, due to the relatively small number of cars at Hay River.

Because of stringent PCB emission requirements, monitoring of the waste oil for PCB's may be required (see section 8.7).

3.4.5 Miscellaneous Contaminants

Trash (welding rods, cigarette butts, rags, etc.) is to be expected to occur in collected waste oil as drums and tanks are often used to store any waste which will fit through the hole in the tank or drum.

In the various collection systems in Alberta, the only contamination problem encountered has been sewage. At Drumheller, Alberta, the public used oil collection tank is

located near the sewage disposal tank. If there is a lineup at the sewage disposal facility, the oil collection tank has been used for sewage disposal. There were 20,000 litres of used oil contaminated in this manner and rendered unsuitable for re-refining.

3.6 PROBLEMS ASSOCIATED WITH BURNING WASTE OIL AS A FUEL

The major problems associated with burning waste oil as a fuel are operational and result from BS&W content.

Erosion

The sedimentary material in waste oil is characteristically abrasive and results in erosion of burner nozzle tips and can cause seal damage. Some rerefiners have experienced low pump durability (6 months versus 5 years normal life expectancy). Other experience indicates burner nozzle tip life of 6 months versus 3 years.

Fouling and Corrosion

The inorganic constituents in waste oil will form various oxides during combustion. These oxides can form corrosive deposits on furnace walls and heat transfer surfaces.

Degradation of the heat transfer efficiency in a boiler or furnace will result in higher flue gas temperature and lower heat transfer surface temperatures. The flue gas passing through the porous ash surfaces may be cooled below the dew point and hence cause corrosion.

Explosion

The probability of explosion occurring as a result of burning used lubricating oil is extremely low, due to the high flash point of used oil.

In the state of Nebraska, an explosion was attributed to the use of used oil. Legislation was enacted limiting the flashpoint to 60°F (15°C) and the maximum combined solids and water to 1%.

The addition of contaminated fuels to used oil at Hay River will decrease the flashpoint significantly.

Operating and Maintenance

The solids content in waste oil requires additional maintenance, eg. ash removal, cleaning out tubes, etc. Also, filters and strainers will have to be maintained more frequently. Water in the fuel can result in fuel line freezing and burner flame-out in smaller units.

3.7 COMPARISON OF WASTE OILS TO OTHER FUELS

Because of the lower cost of waste oil, it is often burned as a blend with fuel oils and coal.

Generally, used oil contains higher concentrations of trace elements (magnesium, calcium, iron, lead, copper, barium, zinc, phosphorus, silver, tin, chromium) than virgin fuels.

No. 6 Fuel Oil

The sulphur content of waste oil is much less than that of No. 6 fuel oil. Burning waste oil in a blend with No. 6 fuel oil will reduce sulphur emissions and corrosion of internal boiler surfaces. Emissions of silicon, sodium, vanadium, and nickel will also be reduced. The presence of pour point depressants and viscosity index improvers in the waste oil may also improve the handling characteristics over No. 6 fuel oil.

While concentrations of other trace elements are higher in waste oil; a 5% blend of waste oil with No. 6 fuel oil would not significantly increase emissions of the elements.

Coal

Coal contains higher concentrations of some trace metals (aluminum, beryllium, boron, calcium, iron, magnesium, manganese, molybdenum, nickel silicon, silver, sodium, sulphur, strontium, titanium and vanadium.) than No. 6 fuel oil and used oils. Generally, except for lead and phosphorus, burning waste oil with coal will decrease emissions per unit of energy output from the combustion.

Many coal fired facilities require emission control devices (eg. electrostatic precipitators). These devices entrap lead with other particulate.

3.8 SAMPLING AND ANALYSIS OF WASTE OIL AT HAY RIVER

During a visit to Hay River in October, 1984, samples of waste oil were obtained from several waste oil producers. These samples were analyzed in Edmonton for fuel properties and levels of contamination. The analyses are presented in the various tables in this section. Properties of typical waste oil are shown for comparison in Table 3.8-7 and 3.8-8.

Sources of Samples

Samples of waste oil were taken from the sources designated in Table 3.8-1:

TABLE 3.8-1: SAMPLES OF WASTE OIL OBTAINED AT HAY RIVER

Sample No.	Source and Type of Waste Oil
A10	ATL, used lube oil
B10	Blend of used oils from Northland Utilities, Fergusson Supply and Freshwater Fish Marketing Corp. (FFMC)
C10	NTCL, Blend of samples from two heavy slops tanks
D1	NTCL, light slops
E1	NTCL, used lube oil
F10	Cominco Mines, Pine Point used lube oils, etc. (from Interior Oil Analytics, Edmonton)

Samples of used oil generated by GNWT Department of Highways and retain from the Esso Bulk Plant could not be sampled.

Sample Collection

A used oil sampling stick on loan from Alberta Environment was used to collect samples from NTCL. The stick is designed to sample through the strata in the tank to obtain a cross section of the tank's contents. As the stick can be extended to a length

of several metres, water and tank bottoms were sampled with the oil. Samples collected in this manner were the only samples which indicated water contamination (eg. presence of 'bottom layer') of the waste oil (Table 3.8-2).

Samples collected at ATL (A10), Northlands Utilities, Fergusson Supply and FFMC (B10), were collected by personnel at those businesses. Water contamination was not noted in these samples. (Lack of water may have been due to good waste management practices or to sampling techniques.)

The sample from Cominco Mines is not representative of waste oil generated at Pine Point. The sample was obtained from Interior Oil Analytics in Edmonton. IOA perform wear metal analysis for Cominco, and small samples of oil are recovered from equipment and shipped to Edmonton. The sample tested for this report was a collection of samples from Interior Oil Analytics. A sample of waste oil from within the Cominco collection system was not obtained.

Samples were allowed to settle for coarse separation of the oil (top layer) and water (bottom layer) phases. The top layer samples were analyzed for Fuel Properties (Table 3.8-3), and metallic contaminants (Table 3.8-4). Chlorine analysis was done for the top and bottom layers to determine the trend for chlorine concentration in the oil and water phases. (Table 3.8-6)

Fuel Properties

The heat content of the samples (Table 3.8-3), was higher than the 18,500 BTU/lb.(43.0 MJoules/kg) which is typical for waste oils. Only the top layer of samples was analyzed; much lower values would be reported for samples with significant water contamination.

TABLE 3.8-2: DISTRIBUTION OF TOP LAYER, BOTTOM LAYER

	Sample Numbers					
	A10 Lube Oil	B10 Lube Oil	C10 Heavy Slops	D1 Light Slops	E1 Lube Oil	F10 Lube Oil
Top Layer %	100	100	35	88	56	100
Bottom Layer %	-	-	65	12	44	-

TABLE 3.8-3: FUEL PROPERTIES OF WASTE OIL SAMPLES COLLECTED AT HAY RIVER

	Sample Numbers					
	A10 Lube Oil	B10 Lube Oil	C10 Heavy Slops	D1 Light Slops	E1 Lube Oil	F10 Lube Oil
Net Heat of Combustion (MJ/kg)	45.13	44.38	44.31	45.03	44.67	44.84
(BTU/lb.)	19,430	19,110	19,010	19,390	19,230(a)	19,310
Flash Point (°C)	114.0	164.0	73.0	47.0	net(b)	214
Pour Point (°C)	-39	-30	+3	-47	-24(b)	-33
Ash (wt%)	0.29	0.65	0.16(b)	0.16	(a)	0.65
Carbon Residue (wt%)	0.54	1.47	0.72	0.53	0.61	0.92
(a) insufficient sample available						
(b) sample had been centrifuged						

19,010 to 19,430
47.0 to 214
-47 to +3
0.16 to 0.65
0.53 to 1.47

TABLE 3.8-4: ELEMENTAL ANALYSIS OF SAMPLES TAKEN AT HAY RIVER

	Sample Numbers						Range
	Al0 Lube Oil	Bl0 Lube Oil	Cl0 Heavy Slops	DI Light Slops	El Lube Oil	Fl0 Lube Oil	
Aluminum (Al)	<3.0mg/l	4.0mg/l	<3.0mg/l	<3.0mg/l	3.8mg/l	23.5mg/l	<3.0 to 23.5mg/l
Barium (Ba)	4.8	13.5	5.0	3.0	11.5	2.4	3.0 to 11.5
Calcium (Ca)	630	625	164	52	290	1320	52 to 1320
Chromium (Cr)	<0.3	2.0	<0.3	<0.3	0.6	<0.3	<0.3 to 2.0
Copper (Cu)	0.8	18.2	3.5	3.2	2.7	17.9	0.8 to 18.2
Iron (Fe)	13.8	100	21.5	17.1	32.0	68	13.8 to 100
Manganese (Mn)	0.3	1.8	0.6	0.8	0.7	1.3	0.3 to 1.8
Magnesium (Mg)	3.8	1100	27.5	32.5	32.5	63	3.8 to 1100
Molybdenum (Mo)	<1.0	<1.0	<1.0	<1.0	1.0	1.0	<1.0 to 1.0
Sodium (Na)	1.6	7.7	5.3	0.9	2.7	11.7	0.9 to 11.7
Lead (Pb)	<2.0	94	430	118	71	100	<2.0 to 430
Sulphur (S)	1660	6000	5600	2600	2000	8900	2000 to 8900
Silicon (Si)	5.1	11.8	<1.5	<1.5	5.8	60	<1.5 to 60
Tin (Sn)	<0.4	1.5	<5.2	1.8	3.5	2.4	<0.4 to 3.5
Zinc (Zn)	455	1020	94	158	99	675	94 to 1020

All units are milligrams/litre

The U.S. Environmental Protection Agency uses a tentative designation of 'hazardous wastes' for wastes with a flashpoint less than 100°F (38.9°C). All of the samples analyzed were above this criterion. Light slops from NTCL (Sample D1) have a flashpoint of 47°C. Flashpoints of the light and heavy slops (C10 and D1) were significantly lower than flashpoints of the lube oils, as expected.

The flashpoint of waste oil fuel for the proposed facility will be determined by the types and volumes of waste oils collected. The presence of contaminated fuels will lower the flashpoint of the combined volumes. The actual reduction cannot be predicted. Small volumes of light (ie. low flashpoint) slops can probably be blended with the waste oil without lowering the flashpoint of the waste oil in the hazardous range.

The Hay River MOT uses contaminated fuels for fire training sessions. The preference is for light fuel with good flame spreading ability. Light slops may be a suitable fuel for their purpose. This would reduce concerns for low flashpoint in collected waste oils.

The flashpoint of used lube oil from ATL (sample A1) was 114°C, i.e. very low for used oils. The flashpoint of virgin lube oil is above 180°C. Contamination of the waste lube oil with fuels is probable. The composite sample (B10) from small producers in Hay River also had a relatively low flashpoint of 164°C. Fuel contamination of at least one of the three used oil systems sampled is probable.

Pourpoint of the samples was generally good, indicating the wastes can be collected during cooler months. The exception is the heavy slops sample from NTCL. The higher pourpoint (+3°C) may require collection during warmer months.

The ash content of the samples was surprisingly low. In Table 3.3-1, the ash content for used automotive oils is given a range of 0.03-3.78% (by weight). Samples of waste oil from Hay River showed a range of 0.16-0.65%; at the low end of the range noted for used oils. The ash content of samples analyzed can be compared favourably to that of No. 6 fuel oil (max. 0.50%, Table 3.3-1).

Metals Analysis

In Table 3.8-4, concentrations of metals in the Hay River samples are given. Lead is the major element of concern regarding possible emissions. Concentration of lead varies from <2.0 mg/l (Lube oil at ATL) to 430 mg/l (heavy slops at NTCL). As no automotive sources of used oil were sampled, the occurrence of lead in the samples must result from contamination of waste oils with leaded fuels (gasoline, av gas) or with used automotive oils. Lead may also occur as a wear metal or as a component of a lubricating additive.

The lead content of the light slops at NTCL (Sample D1) was lower than could have been expected. Leaded fuels are light fuels and would be designated light slops when contaminated.

The lead content in the lube oil samples obtained from ATL (A10) and NTCL (E1) varies significantly, <2.0 mg/l vs. 71 mg/l. The oils are presumed to be of the same type and are from similar sources. The lead concentration for ATL is as expected (eg. diesel engine lube oil). The lead content for NTCL used oil must result from contamination. The magnesium content in the NTCL sample (32.5 mg/l) was also significantly higher than the ATL sample (3.8 mg/l.) The lead and magnesium concentrations are both at the lower ends of ranges described for waste automotive oil.

The ranges of metallic concentration for automotive oils have

been repeated in Table 3.8-5. The ranges for the samples collected at Hay River are also repeated. Sample Fl0, lube oil from Cominco Mines, Pine Point, has been excluded from Table 3.8-4, as the sample is not representative and the oil is not considered to be available to the Town for the proposed facility.

Except for magnesium, sulphur and zinc, all metals analyzed are at the extreme low range of concentration reported in the literature. The highest lead concentration (430 mg/l) is much less than the lower end reported (800 ppm). The highest concentration of zinc noted (1020 mg/l for composite sample B) is less than 1/2 the higher concentration reported (3000 ppm). The concentrations of sulphur and magnesium in samples obtained at Hay River are within the range reported in literature.

Chlorine

Chlorine is of special concern due to possible emissions of dioxins and other organics. Samples were allowed to settle for coarse separation of oil (top layer) and water (bottom layer) phases. Water wash tests for chlorine were performed on the top and bottom layers to determine concentrations (Table 3.8-6).

The U.S. EPA has tentatively designated as a 'hazardous waste' waste oil with a chlorine content above 4000 mg/l. None of the top layers analyzed showed chlorine concentrations in this range. Lube oil samples from ATL, NTCL and Cominco Pine Point indicated chlorine concentrations about 5% of the maximum allowed by EPA. The chlorine concentration in used oils reported in the literature is up to 6000 ppm, a typical value is 1450 ppm (Ref.1).

The ratio of chlorine in top/bottom layers indicates a tendency for chlorine to concentrate in the bottom water layer. If water is settled and decanted from the oil phase then much concern for organic emissions can be eliminated. Disposal of high chlorine content waste water may be a separate issue for concern.

TABLE 3.8-5: COMPARISON OF ELEMENTAL ANALYSIS

	Used Auto. Oils From Table 3.3-1	Hay River Samples From Table 3.8-4 ^a
	Concentration of Contaminant mg/l	
Aluminum	10 - 800	<3.0 - 4.0
Barium	10 - 2,000	3.0 - 11.5
Calcium	700 - 3,000	52 - 630
Chromium	8 - 50	<0.3 - 2.0
Copper	10 - 2,000	0.8 - 18.2
Iron	50 - 2,000	13.8 - 100
Manganese	5 - 10	0.3 - 1.8
Magnesium	10 - 1,100	3.8 - 1,100
Molybdenum	2 - 3	<1.0 - 1.0
Sodium	16 - 300	0.9 - 7.7
Lead	800 - 11,200	<2.0 - 430
Sulphur	2,100 - 6,500	2,000 - 6,000
Silicon	10 - 875	<1.5 - 11.8
Tin	5 - 112	<0.4 - 3.5
Zinc	300 - 3,000	94 - 1020

^a Cominco Pine Point sample not included in ranges reported as used oil not likely to be used at Hay River.

TABLE 3.8-6 CHLORINE DISTRIBUTION IN TOP AND BOTTOM LAYERS

	Al0 Lube Oil	Bl0 Lube Oil	Sample Numbers			El Lube Oil	Fl0 Lube Oil	Range
			Cl0 Heavy Slops	DL Light Slops				
Top Layer volume mg/l	100 202.5	100 45.3	35 45.0	88 14.0		56 170.6	100 242.2	14.0 to 242.2
Bottom layer volume % chlorine mg/l	- -	- -	65.0 1167	12.0 499.4		44.0 593.0	- -	499.4 to 1167

TABLE 3.8-7 PROPERTIES OF WASTE OIL AND RESIDUAL NO. 6 FUEL OIL (Ref. 1 Table 3-6)

Parameter ^b	Estimated Typical Value of Waste Oil	Estimated Typical Value of Residual Fuel Oil
Heat value, Btu/lb	18,500	18,500
Btu/gal	138,000	149,000
API gravity at 60°	26	13-16
Density at 15°C, g/ml	0.8960	
Viscosity at 40°C, centistokes	66.6	350
Water, % wt	2.4	0.08
Ash, % wt	1.16	0.2-0.3
Carbon, % wt	83.9	86.4
Hydrogen, % wt	13.2	12.9
Nitrogen, % wt	0.093	0.3
Sulfur, % wt	0.5	0.2-5
Chlorine, % wt	1.4	
Arsenic, microgm/gm	11	0.2-0.7
Barium, microgm/gm	50	0.3-5.0
Cadmium, microgm/gm	1.1	0.003-1
Chromium, microgm/gm	10	0.7-4
Lead, microgm/gm	220 ^a	1 - 4
Zinc, microgm/gm	469	0.4-2.0

^a This is an average of mixed oils containing both crankcase oil (high in lead) with industrial oils (no lead content)

^b refer to table 3.3-1 for various unit conversion formulas

TABLE 3.8-8 CONTAMINANT CONCENTRATIONS DERIVED FROM
400 WASTE OIL SAMPLES (Ref. 1, Table 3-7)

	Number of Samples	Median Concentra- at 50th percentile, ^a ppm	Concentra- at 75th percentile, ^b ppm	Concentra- at 90th percentile, ^c ppm
Metals:				
Arsenic	17	11	14	16
Barium	159	50	200	485
Cadmium	189	1.1	1.3	4.0
Chromium	273	10	12	28
Lead	227	220	420	1,000
Zinc	232	469	890	1,150
Chlorinated Solvents:				
Dichlorodi- fluoromethane	78	20	210	860
Trichlorotri- fluoroethane	26	<1	33	130
1,1,1-trichloro- ethane	123	270	590	1,300
Trichloroethylene	126	60	490	1,049
Tetrachloro- ethylene	100	120	370	1,200
Total chlorine	62	1,400	2,600	6,150
Other Organics:				
Benzene	32	46	77	160
Toluene	30	190	490	1,200
Xylene	22	36	270	570
Benzo(a)anthracene	17	16	26	35
Benzo(a)pyrene	19	9	12	33
Naphthalene	15	290	490	580
PCB's	264	9	41	50

^a At the median, 50 percent of the analyzed waste oil samples had contaminant concentrations below the given value.

^b Seventy-five percent of the analyzed waste oil samples had contaminant concentrations below the given level.

^c Ninety percent of the analyzed waste oil samples had contaminant concentrations below the given level.

4.0 TECHNOLOGY

4.1 GENERAL

The literature reviewed indicated that waste oil could be burned in virtually any facility designed to burn No. 5 or No. 6 fuel oils, and in most facilities burning No. 4 fuel oil (although modifications may be necessary.) There were no special designs or specific technologies identified as being required or recommended for burning waste oil as a fuel. The literature focussed on the negative aspects of burning waste oil as a fuel, and emphasized the associated technical and operational problems and the potential environmental impact of emissions.

The primary requirements for a waste oil fired heat recovery system are a burner and a heat exchanger compatible with each other and the fuel. Sizing of the equipment is determined by the requirements of the installation (in this case 4.5×10^6 BTU/hour or 1320 kw). Selection of equipment is based on the suitability of the equipment to waste oil firing, and on the availability of operating and maintenance personnel.

Operating and maintenance requirements for waste oil fired systems are higher than virgin oil fired systems. This is primarily due to solids and water contamination in the waste oil, and to the soluble inorganics in the oil. Higher ash, increased fouling, corrosion, deposits, etc., are all characteristic of waste oil fired systems.

In the following sections various types of oil burners and boilers are assessed for suitability to waste oil firing. The actual conceptual design for the proposed waste oil fired heating system at Hay River is given in Section 7.6.

Pre-treatment of waste oil for removal of solids and water is recommended. A system is outlined in Section 8.4, and is

expected to produce a fuel with very low BS&W (eg. <0.5%). This will alleviate, but not eliminate many of the technical and operating problems associated with burning waste oil (fouling, corrosion, emissions, etc.). Soluble inorganics (eg. lead and other trace metals) remain in the fuel and will continue to contribute to operating problems.

4.2 BURNERS

The function of the burner is to introduce air and fuel into the boiler or furnace in a manner which will sustain exothermic chemical reactions for the most effective release of heat. While there is an exact or stochiometric amount of air (oxygen) required per unit of fuel consumed, excess air is introduced to the system to ensure combustion of all combustible components in the fuel. Efficiency of combustion is maximized by a combination of minimizing unburned combustibles and minimizing excess air.

To promote combustion, the fuel is 'atomized' by the burner, dispersing the fuel in the furnace as a fine mist. The fuel droplets have a high surface area for contact with combustion air to assure prompt ignition and rapid combustion of the fuel. There are four basic methods for atomization of fuel in oil-fired boilers: air, steam, mechanical and rotary cup. There is a trend towards mechanical atomization in smaller units, air atomization in large units. Rotary cup burners are described in the literature as having high maintenance requirements, and are the most adaptable to waste oil firing. The following descriptions are summarized from reference 9.

Air Gun Burners: a rotary fuel pump delivers pressurized fuel to a fixed orifice nozzle, where a whirling conical spray is produced. Low pressure air is swirled concentrically with the fuel to provide good combustion. These burners usually operate at a fixed firing rate. Heat demand is satisfied by an on-off operation. In small installations, gun burners can handle fuel equivalent to No. 4 fuel oils. The spray pattern will deteriorate with heavier fuels.

High pressure mechanical and steam atomizers are used in larger boiler installations. These are gun type burners with the addition of high pressure air or steam to assist atomization. The pressures required are 150 psi steam or 300 psi air for the

mechanical type atomizers. Nozzles are designed to provide the desired atomization and spray patterns. The steam type atomizer adds a separate stream of steam to the fuel oil prior to entry to the nozzle.

Some mechanical atomizers are capable of variable firing rates. A fuel supply back pressure regulator controls the fuel flow rate.

Nozzle type burners (high pressure or low pressure) are extremely susceptible to clogging due to particulate in the fuel. Blending waste oil with virgin fuels will reduce this effect. Selection of a nozzle type burner will depend on viscosity of the fuel. A wide range of viscosities cannot be tolerated.

Rotary Cup Burners use centrifugal force to atomize the oil. The cup is mounted on a horizontal shaft which spins at high speed (5,000 to 6,300 rpm). Oil is pumped at low pressure into the conical spilling cup. The centrifugal action causes the oil to distribute evenly over the inner surface of the cup and be thrown off the rim of the cup as a thin film. Air from a fan (also located on the shaft) is blown concentrically around the cup, atomizing the film of oil. Firing rate is controlled by regulating the feed of fuel to the cup. The atomizing mechanism is dependent on the speed of the cup and can be varied for different viscosities of fuel.

As noted earlier, the viscosity of the fuel is a major consideration when determining the type of burner to be used. The recommended viscosity operating ranges for the different types of burners are given in Table 4.2-1. Heating the fuel will have a dramatic effect on viscosity as shown in Table 4.2-2.

Table 4.2-1 RECOMMENDED FUEL VISCOSITY FOR FOUR TYPES OF
BURNERS

<u>Burner Type</u>	<u>Recommended Viscosity (SUS)</u>
Low pressure	85-100
High pressure	125-150
Steam	150-200
Rotary	200-250

Reference 9:

Staybolt Universal Seconds (SUS) = .4717 x centistokes

TABLE 4.2-2 VISCOSITY AS A FUNCTION OF TEMPERATURE FOR
HEAVY (NO.6) OIL

<u>Temp. °F</u>	<u>Viscosity (SUS)</u>
130	1250
140	850
150	220

Reference 9

If waste oil is preheated prior to burning the viscosity will be affected in a similar manner. The actual viscosity of the waste oil will depend on the components of the fuel (lubricating oils, contaminated fuels, solvents, etc.). The viscosity range for used automotive oils given in Table 3.3-1 is 87-837 SUS (100°F). This can be compared with No. 2 distillate oil (32-40 SUS @ 100°F) and No. 6 residual (48-3400 SUS @ 100°F).

In Table 3.8-7, a viscosity of 66.6 cs (equivalent to 308 SUS @ 100°F) is given for a 'typical' waste oil. This oil is a mixture of automotive and industrial oils and is taken as representative of the waste oil for collection at Hay River. The waste oil fuel will likely have to be heated above 40°C to produce the desired viscosity range.

4.2.2 Operation of Saacke Rotary Cup Burner (Dome Petroleum)

The Saacke Rotary Cup is the burner most commonly associated with burning waste oil in the MacKenzie Delta. This is due to the successful operation of a Saacke burner by Dome Petroleum. The primary function of the unit is for disposal of oil recovered from spills. The system is designed to handle high water contamination, and is transportable for use in remote locations. Secondary use of the system is for disposal of slops at the Tuktoyaktuk shore base.

The unit is significantly larger than the proposed facility at Hay River. It is capable of burning 3,300 litres/hour (500 bbl/day) compared to the 110-120 litres/hour at the proposed facility. The Saacke burner at Tuktoyaktuk is operated as a disposal system and is not designed for heat recovery. The following are observations regarding the system at Tuktoyaktuk:

Operation: The unit is attended by two full time operators. There is no combustion chamber enclosing the burner and the burner must be directed downwind for efficient operation.

There is a preheater to heat the waste oil if required.

Slops and oils are not mixed prior to burning. A wide range of viscosities are burned. Adjustment of cup speed will compensate for this variance.

Solids Content: When burning waste oil contaminated with drilling mud, the barite has caked on the burner and caused the burner to vibrate.

Minor deposits of carbon inside the cup will affect alignment and possibly damage the cup. Periodic cleaning of the cup is recommended. The cleaning period has not been specified.

The Saacke unit is considered sensitive to solids contamination. At the shore base, waste is filtered (in line filter) for removal of sediments prior to burning.

Water Content: The Saacke burner is capable of atomizing up to 60% water-in-crude emulsions. At the shore base, the unit is not used for disposal of waste with high water contamination. Slops are decanted prior to burning. If the waste water is clear, it is discharged to Tuktoyaktuk Harbour. If the wastewater is dirty, it is evaporated in front of the burner.

Emissions: No measurement for emissions from the Saacke unit has been done. The unit has been described as very clean burning with low soot emission. At excessive feed rates, incomplete combustion occurs and considerable smoke is created.

The inorganic contaminants in the waste oil are not likely destroyed during burning and will be discharged directly to the environment as particulate. There is no stack or emission control system.

Because of the presence of drilling muds, the inorganic content of waste oil at Tuktoyaktuk is assumed to be significantly higher than that in waste oil collected at Hay River. Concentration of organic solvents could also be higher in the waste oil at Tuktoyaktuk base.

4.2.3 Burners Suitable for the Hay River Facility

The rotary cup and the high pressure mechanical atomizer are identified as being suitable burners for the proposed facility. The low pressure gun type burner is limited by the viscosity range (85-100 SUS) that can be handled, and by the susceptibility to clogging. The assumed viscosity of the oil (300 SUS) can be handled by the high pressure steam atomizer, but there is no capability for steam production at the pumphouse.

Additional preheating may be required to obtain the desired viscosity range (100-150 SUS) for a high pressure burner. An air compressor would be required to produce 300 psi air. Pretreatment of waste oil for removal of solids will alleviate the problems of clogging at the nozzle. Regular maintenance would still be required.

The estimated cost of a high pressure burner is \$7-10,000 and a preheater would cost \$3,000. The additional cost for the air compressor is estimated to be \$2,000. Replacement nozzles are \$200 to \$300 each, and nozzles replacement may be required every 6 months to one year when burning a blend of waste oil and virgin fuel. Nozzle replacement when burning virgin fuels alone is typically 3-7 years. The replacement period for 100% waste oil

is not known, but it is likely to be more frequent than for blends (eg. 3-6 months).

The rotary cup is considered to be more adaptable to burning waste oil than the high pressure burner. Firing rates and viscosity can vary over wide ranges. As there are no orifices or nozzles, clogging by particulate in the fuel is not a problem. Maintenance of the burner is still required; i.e., cleaning of the cup for removal of soot and sediment. Build-up of deposit in the cup can affect operation of the burner. The \$20,000 cost of a rotary cup burner is the same from two European manufacturers; Hamworthy (Great Britain), and Saacke (Germany).

The rotary cup burner is nominated for use at the proposed Hay River facility, as discussed in section 7.6.

4.3 BOILERS

There are two basic types of oil fired boilers: water-tube and fire-tube. Water-tube boilers are generally the largest units with the greatest range in capacity. In a water-tube boiler, the hot gases from combustion of fuel contact the exterior surface of the heat transfer tubes. Boiler water and steam flow through the tubes. This type of boiler is usually used for generation of high pressure and high temperature steam. The two existing units in the intake pumphouse at Hay River are both water-tube boilers. Their capacities are 2.4×10^6 and 4.6×10^6 BTU/hr. (1350 kw).

In a fire-tube boiler, hot combustion gases flow from the combustion chamber through the heat transfer tubes. The combustion chamber is enclosed in a boiler shell and boiler water in the shell absorbs heat from the heat transfer tubes. Fire-tube boilers are generally smaller than water-tube boilers. Cast iron boilers are a special type of fire-tube boiler. They are more tolerant of overloading or demand surges.

The types of boilers which are more likely to be fired with waste oil are the fire-tube and cast iron units. Because combustion gases flow through the heat transfer tubes, fouling and deposits will occur within the tube. Cleaning the interior of the tubes for removal of ash, soot and deposit, is much easier than cleaning the exterior surfaces. In a water tube boiler, tubes can be very densely packed and cleaning the exterior surfaces can be very difficult.

4.4 INCINERATION

Consideration has also been given to dual chamber incineration at the proposed facility in Hay River. The potential advantages of controlled air incineration are:

- 1) potential emissions of particulate suspended in flue gas are reduced.
- 2) potentially more complete combustion of organics can occur due to longer residence times and higher temperatures.
- 3) with the appropriate burner, significant quantities of contamination in the fuel can be tolerated. Disposal requirements for waste water and sludge can be reduced or eliminated.

Incinerators are commonly used for disposal of pathological and hazardous chemical waste.

In a typical configuration of a dual chamber, controlled air incinerator, waste is fed to the lower or ignition chamber. Moisture in the feed is evaporated and with the volatiles, passed to the upper (combustion) chamber. Combustion air is minimized in the lower (ignition) chamber and starved-air conditions exist (insufficient oxygen for complete combustion). Fixed carbon (non-volatile combustible component of the fuel) is burned in the lower chamber.

Volatiles are burned in the combustion chamber, in the presence of excess air. The mixing of the volatiles and air takes place in the flame port area. Subsidiary fuel may be required to maintain a minimum temperature (1600 to 1800 °F or 900°C - 1000°C) in the upper chamber. Auxillary fuel may also be required in the lower chamber if the heat content of the waste is insufficient.

The inorganic components of the fuel remain in the lower chamber. Non-turbulent conditions are maintained and entrainment of particulate matter in the combustion gases is minimized.

A liquid waste burner described above, is similar to the Vertech ECP incinerator. The burner is a nozzle type burner (but no fixed orifice) which uses superheated air or steam to atomize the liquid waste. Radiant heat of the flame is used to superheat the air or steam for atomization. Air at 100 psig is required (steam is not available at the pumphouse).

The system is reportedly capable of handling significant water contamination in the fuel (up to 50-60%). This would eliminate the need for a waste water residue disposal system provided the oil and water can be mixed in such a way to prevent slugs of water entering the burner resulting in burner flame out and the need for auxillary fuel.

The need for a pre-treatment system for removal of solids and water can be eliminated completely if it can be shown that:

- 1) the burner can tolerate particulate in the fuel, and
- 2) inorganic content of the fuel does in fact remain in the lower chamber, and does not contribute to particulate emissions and fouling of the heat transfer surfaces.

4.5 DEPOSITS AND CORROSION

Fuel ash does not have a single defined melting point. The ash has a complex chemical composition and will soften and melt over a wide range of temperatures. Ash particles in a semi-molten state at the temperature of the boiler tube surfaces may adhere to the tube if brought into contact with the tube by gas flow. Dry ash particles may also adhere to tubes due to mutual attraction or surface roughness. If an initial deposit layer is formed, the surface of the layer is at an even higher temperature than the tube surface, due to low thermal conductivity of the deposit. The increased temperature will promote increased deposits. Sodium and vanadium are of most concern, Both metals form a range of compounds with low melting temperatures (220-700°C).

Molten ash can be absorbed by porous refractory surfaces in furnaces. At varying loads and temperatures, the surface will expand and contract, causing the refractory to spall and break down. This problem is also a function primarily due to formation of sodium and vanadium compounds.

The overall effect of corrosion and deposits is to reduce the heat transfer coefficient of the boiler tubes and reduce the boiler efficiency. Increased operating and maintenance costs are faced for removal of deposits and replacement of tubes.

5.0 EMISSIONS

5.1 GENERAL

Emissions from a facility burning waste oil as a fuel are a function of contaminants and composition of the waste oil, design of the combustion unit and control equipment, burner type, operating parameters, unit capacity and fuel rate. Emissions may be the result of contaminants in the fuel (eg. lead, PCB's) or they may be the products of incomplete combustion (carbon monoxide CO, carbonaceous particles, dioxins). Many of the major contaminants in waste oil are not destroyed during combustion, and they do not decay in the environment. The emissions of most concern when burning waste oil are metals, halide acids and organics (solvent and chlorinated organics).

Pre-treatment of the waste oil for the removal of solids and water will have an immediate effect of reducing potential emissions. All particulate matter is removed from the waste oil during centrifuging. There is evidence that the concentrations of lead and other metals in the fuel are also reduced through centrifuging (Ref. 1). Some heavy metals which are soluble in the oil will not be affected by pre-treatment of the oil. These metals will subside into the ash residue or will be emitted to the atmosphere as a sub-micron sized particulate matter.

Chlorinated organics are soluble in both oil and water, there may be a slight tendency towards concentrating in the water phase. Removal of the water from the waste oil will result in some removal of chlorinated organics from the fuel.

The halide acids (eg. Hydrogen Chloride, HCl) are not contaminants in the fuel. They are assumed to be formed during combustion of the waste oil (eg. HCl is formed from chlorinated organics in the fuel.)

In section 5.4, air quality impact modelling by PEDCo Environmental Inc. is reviewed. The model is for emissions from a single source burning used lubricating oils as a fuel. This model is loosely applied to the proposed waste oil fuel (Table 3.8-7) at Hay River. Emissions of lead and barium are found to have a potentially significant impact on the environment. A lead concentration of 220 mg/l in the feed fuel resulted in maximum 30 day ambient air concentration of 0.024 ug/m³ (10 m stack, 50% lead in fuel emitted) in the model. The Canadian Environmental Protection Service (EPS) has suggested a maximum 30 day ambient air concentration of 2 ug/m³ for lead. A barium concentration of 50 mg/litre in the feed fuel resulted in a maximum 30 day ambient air concentration of 0.008 ug/m³ (75% barium in fuel emitted). There are no standards for emission of barium. The threshold limit value for barium is 0.5 ug/m³. (i.e. a worker can be exposed to 0.5 ug/m³ barium for 8 hrs/day, 5 days/week over 40 years).

There are no federal or territorial regulations for emissions from a facility burning waste oil as a fuel. EPS has suggested that Secondary Lead Smelter Regulations, part of the Federal Clean Air Act may apply. These standards are given in Section 5.5 along with the other relevant sections of the act.

Ground level concentrations for secondary lead smelters which have been adopted in Ontario (and other provinces) are:

24 hour sample:	5 ug/m ³ (micrograms/cubic metre)
30 day sample:	2 ug/m ³

These lead emission standards might be applied to the facility at Hay River.

5.2 METALS

At high temperatures in the flame zone, lead, zinc and other trace metals undergo secondary reactions and form volatile species. These species subsequently condense and appear in the flue gas as sub-micron sized particles.

The metal emissions of most concern are arsenic, barium, cadmium, chromium, lead and zinc. Concentrations of these metals in a 'typical waste oil' (representative of waste oil collected at Hay River - See Tables 3.8-7 and 3.8-8), are given in Table 5.2-1. The concentrations at the 90th percentile of over 400 samples of waste oil are also given (Ref. 1).

TABLE 5.2-1: CONCENTRATION OF METAL CONTAMINANTS IN TYPICAL WASTE OIL AND AT 90TH PERCENTILE OF 400 SAMPLES

Metal	Concentration in Typical Waste Oil ^b (Table 3.8-8) microgram/gm	Concentration at 90th Percentile ^a (microgram/gm)
Arsenic	11	16
Barium	50	485
Cadmium	1.1	4.0
Chromium	10	28
Lead	220	1000
Zinc	469	1150

Source (Ref 1, Table 3-7)

a : 90% of the samples analyzed had contaminant concentrations below the given value

b : 'typical waste oil' represents 50 percentile of the same 400 samples (i.e. 50% of the samples analyzed had contaminant concentrations below the given value.)

TABLE 5.2-2 PARTICLE SIZE DISTRIBUTION OF SOME MAJOR CONTAMINANTS IN EMISSIONS FROM WASTE OIL COMBUSTION
(wt. % of the contaminant falling within the indicated particle size range)

Particle Size	Lead	Calcium	Phos-	Zinc	Iron	Barium
<1 micrometre	76-79%	10-19	23-42	56-73	2.7-36	3.3-51
1-10 micrometres	16-21	71-74	49-66	23-39	51-80	40-79
>10 micrometres	2.7-4.4	10-15	8.9-10	3.4-5.0	13-80	8.9-18

Source (Ref. 1)

TABLE 5.2-3 PARTICLE SIZE DISTRIBUTION OF UNCONTROLLED EMISSIONS FROM A NO. 6 FUEL OIL-FIRED BOILER

Aerodynamic diameter size range, micrometres	Weight %
<1	20
1-3	1
3-10	74
>10	5

Source (Ref. 1)

The metals are emitted as particulates, Table 5.2-2 shows the weight distribution of size ranges in the emissions of some metal contaminants. For most metals, 90% of emissions are 10 microns in size or smaller. This is the respirable range and provides the most danger to human health. In comparison, for a facility burning No. 6 fuel oil, 95% of particulate emissions are less than 10 microns in size. (Table 5.2-3)

Emission of metals is dependent on the metal and the concentration of the contaminant in the feed. The rate of emissions is indicated in Table 5.2-4. Emissions range from 31-75% of the contaminant in the fuel. These values are averages, as individual emissions vary from 20-100%. (Emission rates for arsenic, barium, cadmium, and chromium are an average of 2 data points. Lead and zinc are an average of 5 data points.)

A separate survey by the U.S. EPA indicated that lead emissions average 50% of lead in feed. This is the value most widely reported in the literature.

There was little data found in the literature to relate the contaminant level in the fuel to the contaminant level in the particulate emissions. One report (Ref 2) cited a test at Humble's Baltimore Terminal. The burn test was for a blend of used oil in Bunker fuel (up to 15.2% used oils):

- 1) lead emissions (lb/hr) increased with increased lead in fuel
- 2) lead content of particulate emissions (eg. weight percent) increased with increased lead in fuel.
- 3) ratio of lead in fuel/lead in emissions (eg. lead in/lead out) decreased with increased lead in fuel.

The Humble test reported lead concentrations in the particulate matter of 0.3% by weight (0% used oil in fuel) to 23.8% by weight (15.2% and 13.8% used oil in fuel). The same report cited a separate test by ESSO Engineering and Research which showed the metal concentrations in the particulate as in Table 5.2-5. The

boiler in the ESSO test burned 100% used oil of unspecified composition.

TABLE 5.2-4: STACK EMISSION OF METAL CONTAMINANTS AS A PERCENTAGE OF THEIR PRESENCE IN THE FEED FUEL

<u>Metal</u>	<u>% Emitted</u>
Arsenic	70%
Barium	58
Cadmium	40
Chromium	31
Lead	64
Zinc	75

Source: Ref 2

TABLE 5.2-5: CONCENTRATION OF METALS IN PARTICULATE EXPRESSED AS A WEIGHT % OF TOTAL EMISSIONS

	<u>Range</u>	<u>Average</u>
Lead	14-19%	16%
Calcium	8-13	10
Phosphorus	6.1-7.7	6.9
Zinc	3.7-5.0	4.3
Iron	0.9-1.3	1.1
Barium	1.2-2.6	1.9

Source: Ref. 2

5.3 ORGANICS

Organic emissions may result from contaminants (PCB's) in the feed fuel, due to incomplete combustion (hydrocarbons, carbon monoxides), or due to formation during combustion (dioxins).

Polynuclear aromatics (PNA's) and polycyclic organic matter (POM's) may be found in all heavy fossil fuels and are not considered a contaminant in waste oil. PNA's are known carcinogens.

There is limited test data available for organic emissions from waste oil burning facilities. Mostly undetectable levels are shown.

The Destruction Removal Efficiency (DRE) is a measure of destruction of organic compounds. Tests done for the U.S. EPA have confirmed that DRE's are usually better than 99%, in some cases slightly lower.

Atmospheric Half-Life

Organic contaminants in waste oil have a finite half-life in the atmosphere. Eventually, they transform to simpler forms as a result of sunlight or the presence of other chemicals in the atmosphere. The atmospheric half-lives of some of the compounds of interest are given in Table 5.3-1.

TABLE 5.3-1: Atmospheric Half-Lives for Specific Compounds

Carbon Tetrachloride	< 8 hrs.
Tetrachloroethylene	20 - 40 hrs.
Toluene	5, 7 hrs.
1,1,1 Trichloroethane	>>1700 hrs.
1,1,2 Trichloroethane	20 - 40 hrs.
Trichloroethylene	5 - 12 hrs.

Source: Ref 1

Dioxins & Furans

Dioxins and Furans are not contaminants generally found in waste oil. They may be formed during combustion of waste oil as a result of the presence in the waste oil of precursors to dioxins and furan formation. Some dioxins are extremely toxic and the health impacts of dioxin emissions are potentially significant.

Polychlorinated dibenzodioxins (PCDD's) and polychlorinated dibenzofurans (PCDF's) are subsets of a larger group, polyhalogenated aromatic hydrocarbons. PCB's are members of the same set.

Dioxins and furans emitted from combustion processes are associated with the particulate matter. Both compounds have been detected in the ash from facilities burning waste oil. The feed fuel was not sampled and analyzed for the presence of the compounds or the precursors to formation.

Precursors to dioxin formation have not yet been specifically identified; chlorinated phenols and chlorinated benzenes are possibilities. Polyvinylchloride (PVC) forms chlorinated benzenes during combustion. A different theory proposes that low concentrations of either inorganic or organic chlorides in the fuel can be expected to produce PCDD's.

The formation of PCDF's is possibly due to the presence of PCB's which act as a precursor.

5.4 AMBIENT AIR QUALITY IMPACT MODELING

5.4.1 General

PEDCo Environmental Inc. have recently completed a final report (Ref. 1) which analyzes the burning of waste oil as a fuel and evaluates the associated risks to the health of the exposed population.

Hazardous contaminants in waste oil which exhibit a threshold response level (ie. a level below which no adverse effects are observed) are designated threshold contaminants. Non-threshold contaminants are those for which no safe level is known (eg. carcinogens). Table 5.4-1 lists threshold and non-threshold contaminants which may occur in waste oil.

TABLE 5.4-1 THRESHOLD AND NON-THRESHOLD CONTAMINANTS
IN WASTE OIL

Threshold	Non-Threshold
Barium	Arsenic
Cadmium	Chromium
Chromium	1,1,2-Trichloroethane
Lead	Tetrachloroethylene
Zinc	Trichloroethylene
1,1,1-Trichloroethane	Carbon Tetrachloride
Toluene	PCB's
Hydrogen Chloride	Dioxins

Source: Ref 1

-

Environmental Exposure Levels

Threshold Limit Values (TLV's) have been developed to represent 'safe' 8 hour exposure levels. They are designed for a work lifetime exposure (8 hour/day, 5 days/week, 50 weeks/year, 40 years) and are usually directed at the typical adult male worker.

Environmental Exposure Levels, or EEL's, are TLV's modified to account for:

- 1) lifetime versus work week exposure, and
- 2) exposure to the most susceptible portion of the population.

TLV's and EEL's for threshold contaminants which may occur in waste oil are given in Table 5.4-2.

5.4.2 PEDCo Modelling for Ambient Air Impact

The PEDCo report uses the Industrial Source Complex (ISC) model to estimate ground level concentrations of threshold contaminants around a single point source. Non-threshold contaminants are not modelled for single source emissions, but ambient concentrations can be extrapolated from the threshold contaminant data. Maximum 30 day ambient air concentrations are determined.

The results of the threshold contaminant modelling by PEDCo are given in Table 5.4-3. The source of emissions is a 5 million BTU/hour boiler burning 100% waste oil at 50% capacity. (i.e. maximum feed rate = 132 litres/hour; feed rate for modelling = 66 litres/hour). Three stack heights of 10, 15, and 20 metres are given, stack diameter for each case is 0.6 m.

The following assumptions are made for the modelling;

- 1) concentrations of contaminants in the waste oil fuel represent the 90th percentile concentrations of nearly 400 samples of waste oil (90% of samples analyzed had contaminant concentrations below the given value).
- 2) 75% of metals in feed are emitted in the flue gas.
- 3) Destruction removal efficiency (DRE) for organics is 97%.
- 4) HCl emissions equal 100% of chlorinated organics in feed.

TABLE 5.4-2 THRESHOLD LIMIT VALUES AND ENVIRONMENTAL EXPOSURE LEVELS FOR HAZARDOUS CONTAMINANTS IN WASTE OIL. (REF 1 Table E-3, E-4)

Substance	ACGIH TLV ^a 8-h TWA, mg/m ³	Targeted Prevention	Selected Uncertainty (safety factor)	Derived EEL ₃ ug/m ³
Barium	0.5	Excitability	100	0.43
Cadmium Compounds	0.05	proteinuria, pulmonary edema, and emphysema	10	0.34
Chromium	0.5	Pulmonary edema and irritation	10	4.32
Hydrogen Chloride	7.0 (5ppm)	Irritation	10	59.7
Lead	0.15	Encephalopathy and renal damage	10	1.50 ^b
Naphthalene	50.0	Irritation	10 ^a	43.2
Xylene	435.0 (100ppm)	Narcosis, chronic	10	3,758
Zinc (as zinc oxide)	5.0	Reduced incidence of metal fume fever	10	43.2
Toluene	375.0 (10 ppm)	Loss of muscle coordination and cardiomuscular changes	10	3,240
Trichloroethane (1,1,1-)	1900.0 (350ppm)	Anesthetic effects and objectionable odor	10	16,416

a) TLV developed by American Conference of Government Industrial Hygienists. (ACGIH)

8-h TWA denotes 8 hour workday time weighted average

b) Ambient Air Quality Standard of 1.5 ug/m³ used instead of estimated EEL (1.3 ug/m³).

TABLE 5.4-3: AMBIENT AIR IMPACT FOR THRESHOLD CONTAMINANTS
(75% OF METALS IN FEED EMITTED)

Threshold Contaminant	Concentration in Feed (mg/litre)	Ambient Air Concentrations for Stack Height			EEL ₃ ug/m ³	Max. % EEL
		10 m	15 m	20 m		
Barium	485	0.080	0.036	0.020	0.43	18.68
Cadmium	4.0	<0.001	<0.001	<0.001	0.34	<1
Chromium	28	0.005	0.002	0.001	4.32	<1
Lead	1,000	0.164	0.074	0.040	1.5	10.9
Zinc	1,150	0.189	0.086	0.046	43.2	<1
Toluene	1,200	0.008	0.004	0.001	3,240	<1
Trichloroethane	1,300	0.009	0.004	0.001	16,420	<1
Hydrogen Chloride	6,150	1.35	0.62	0.33	59.7	2.3
Napthalene	580	0.003	0.002	0.001	432	<1

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Source: Ref. 1

ug/m³ = micrograms/cubic metre
EEL = Environmental Exposure Limit

- 5) The meteorological conditions used in the model are for JFK Airport (New York) during the month of January. The data included windspeed and direction (prevalent west and northwest, atmospheric stability, monthly averaged mixing heights (900-1325 m) and the monthly averaged ambient temperatures (-4 to +3°C).

Results of the ISC modelling are shown in Table 5.4-3.

Of the threshold contaminants, barium, lead and hydrogen chloride can be considered to make a potentially significant contribution to the EEL. In the model, a lead concentration of 1000 mg/litre in the fuel can result in ambient air concentration of 0.164 $\mu\text{g}/\text{m}^3$ (for boiler with 10 m stack). This concentration represents 10.9% of the EEL (1.5 $\mu\text{g}/\text{m}^3$) indicating a potential health risk and impact on air quality.

From the results of Table 5.4-3, Tables 5.4-4 through 7 can be extrapolated. Table 5.4-4 relates the concentration of metallic contaminants in the feed to the ambient air quality with 75% of metals in the feed being emitted. Table 5.4-5 assumes 50% of metals in the feed are emitted. For a lead concentration of 500 ppm in the feed, and 75% emission, the ambient air concentration of lead is 0.082 $\mu\text{g}/\text{m}^3$ (10 m stack). If the emission rate is reduced to 50% of feed (standard accepted emission rate for lead), the ambient air concentration of lead is 0.054 $\mu\text{g}/\text{m}^3$, 3.6% of the EEL. The tables can be used for metals other than lead.

Table 5.4-6 gives ambient air impact for a range of concentrations of chlorinated solvents and other organics. The destruction removal efficiency is assumed to be 97% (ie. 3% of organics emitted). Table 5.4-7 gives ambient air impact for a range of concentrations of total chlorine. HCl emissions are assumed to be 100% of total chlorinated organics.

TABLE 5.4-4 AMBIENT AIR IMPACT OF METALLIC CONTAMINANTS
FROM COMBUSTION OF WASTE OIL
75% METALS IN FEED EMITTED

STACK HEIGHT	Concentration of Metal Contaminants in Waste Oil Feed Fuel							
	3,000 ug/m ³	1,000	500	200	100	50	25	10
Concentration of Metal Contaminants in the Ambient Air								
10 metres	0.491 ug/m ³	0.164	0.082	0.033	0.016	0.008	0.004	0.002
15 metres	0.223	0.074	0.037	0.007	0.007	0.004	0.002	<0.001
20 metres	0.121	0.040	0.020	0.009	0.004	0.002	0.001	<0.001

Source: Ref. 1

TABLE 5.4-5 AMBIENT AIR IMPACT OF METALLIC CONTAMINANTS
FROM COMBUSTION OF WASTE OIL
50% METALS IN FEED EMITTED

STACK HEIGHT	Concentration of Metal Contaminants in Waste Oil (ug/m ³)							
	3,000 ug/m ³	1,000	500	200	100	50	25	10
Concentration of Metal Contaminants in the Ambient Air								
10 metres	0.327 ug/m ³	0.109	0.054	0.022	0.011	0.005	0.003	0.001
15 metres	0.149	0.050	0.025	0.010	0.005	0.002	0.001	<0.001
20 metres	0.081	0.027	0.013	0.005	0.003	0.001	<0.001	<0.001

Source: Ref. 1

TABLE 5.4-6

AMBIENT AIR IMPACT OF CHLORINATED SOLVENTS AND OTHER ORGANICS
FROM COMBUSTION OF WASTE OIL
DESTRUCTION REMOVAL EFFICIENCY 97%

STACK HEIGHT	Concentration of Chlorinated Solvents & Other Organics in Waste Oil (ppm)				
	5,000 ppm	3,000	1,000	500	200 100
10 metres	0.035 ppm	0.021	0.007	0.003	0.001 <0.001
15 metres	0.016	0.010	0.003	0.002	<0.001 <0.001
20 metres	0.005	0.003	0.001	<0.001	<0.001 <0.001

Source: Ref. 1

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TABLE 5.4-7 AMBIENT AIR IMPACT OF HCl FROM COMBUSTION OF WASTE OIL

STACK HEIGHT	Concentration of Total Chlorine in Waste Oil (ppm)				
	30,000 ppm	10,000	5,000	3,000	1,000 500 100
10 metres	6.58 ppm	2.19	1.09	0.66	0.22 0.11 0.02
15 metres	3.00	1.00	0.50	0.30	0.10 0.05 0.01
20 metres	1.60	0.53	0.26	0.16	0.05 0.03 <0.01

Source: Ref. 1

HCl emissions in the model contributed 2.3% to the EEL (Table 5.4-3). At higher concentration (10,000 ppm or 1% chlorine in fuel) the ambient air concentration is 2.5 ug/m^3 (10 m stack), and the contribution to the EEL is more significant ($2.5/59.7 = 4.2\%$).

5.4.3 Hay River Air Quality Impact

Using Tables 5.4-4 through 5.4-7 which are based on the ISC modelling done by PEDCo, ambient air impact for a 'typical waste oil' (Table 3.8-7) can be developed. In section 3.8, the concentration of contaminants in this typical waste oil were assumed to be representative of waste oil at Hay River. The assumptions made in the PEDCo modelling are still in effect except the concentrations of hazardous contaminants in the oil are much lower. Ambient air impact for both threshold and non-threshold contaminants in the typical waste oil have been postulated in Table 5.4-8 (75% metals emitted) and Table 5.4-9 (50% metals emitted).

Application of the PEDCo modelling to determine ambient air impact at Hay River is not necessarily valid. The model has not been proven with actual testing for emissions from waste oil burning facilities. However, the model can be used to give an indication of emissions at Hay River, since the proposed facility at Hay River is an equivalent size boiler to the unit modelled (5×10^6 BTU/hr or 1465 kw).

The PEDCo model indicated that emissions of barium, lead and hydrogen chloride were potentially significant. Application of the PEDCo model to Hay River (i.e. typical waste oil, Table 3.8-7) indicates barium and lead emissions are of potential concern. A lead concentration in the fuel of 220 mg/l contributes 2.4% (75% emitted) or 1.6% to 50% emitted to the EEL at Hay River. A barium concentration of 50 mg/l contributes 1.8% (75% emitted) or

TABLE 5.4-8 HAY RIVER AMBIENT AIR IMPACT, TYPICAL WASTE OIL
75% METALS IN FEED EMITTED
100% CHLORINE EMITTED AS HCl

Contaminant	Concentration in Feed (ppm)	Stack Height			EEL	Max. % EEL
		10 m	15 m	20 m		
Ambient Air Concentrations ug/m ³						
Chlorine	1,400	0.30	0.14	0.07	59.7	<1
Arsenic	11	0.002	<0.001	<0.001	N/A	N/A
Barium	50	0.008	0.004	0.002	0.43	1.8
Cadmium	1.1	<0.001	<0.001	<0.001	0.34	<1
Chromium	10	0.002	<0.001	<0.001	4.32	<1
Lead	220	0.036	0.016	0.009	1.5	2.4
Zinc	469	0.077	0.035	0.019	43.2	<1

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TABLE 5.4-9 AMBIENT AIR IMPACT, TYPICAL WASTE OIL
50% METALS IN FEED EMITTED
100% CHLORINE EMITTED AS HCl

Contaminant	Concentration in Feed (ppm)	Stack Height			EEL	Max. % EEL
		10 m	15 m	20 m		
Ambient Air Concentrations ug/m ³						
Chlorine	1,400	0.30	0.14	0.07	59.7	<1.0
Arsenic	11	0.001	<0.001	<0.001	N/A	N/A
Barium	50	0.005	0.002	0.001	0.43	1.2
Cadmium	1.1	<0.001	<0.001	<0.001	0.34	<1
Chromium	10	0.001	<0.001	<0.001	4.32	<1
Lead	220	0.024	0.011	0.006	1.5	1.6
Zinc	469	0.051	0.023	0.012	43.2	<1

1.2% (50% emitted) to the EEL.

Analysis of samples at Hay River (Table 3.8-4 and 3.8-5) showed concentrations of barium and chlorine significantly lower than the concentrations modelled here. At the highest concentration of barium found at Hay River (11.5 mg/litre) the ambient air impact is 0.002 ug/m^3 (75% emissions, 10 m stack), less than 1% of the EEL. At the highest concentration of chlorine found at Hay River (202.5 mg/litre), ambient air impact is 0.04 ug/m^3 , less than 1% of the EEL.

Lead concentration in samples analyzed at Hay River varied from <2 mg/litre to 430 mg/litre, the concentration of lead modelled here (220 mg/litre) is mid-range. The ambient air impact for 50% emission of lead is 0.024 ug/m^3 , or 1.6% of the EEL. There are no federal or territorial regulations for lead emissions from this type of facility. EPS has suggested the application of secondary lead smelter regulations which are based on best practicable control, and which one or more provinces have used to set ground level concentrations:

24 hour, not to exceed 5 ug/m^3

30 day, not to exceed 2 ug/m^3

The value from the modelling here (0.024 ug/m^3) is 1.2% of the acceptable 30 day emission rate. If the error in applying the PEDCo modelling is an order of magnitude, the corrected ambient air concentration (0.24 ug/m^3) is still well within the allowable 30 day emissions.

Non-Threshold Contaminants

There are no Environmental Exposure Levels or Threshold Limit Values for non-threshold contaminants, as no safe level of exposure is known. The effect of non-threshold contaminants in

the feed fuel at Hay River can be examined by considering the ambient air impact from a single source burning waste oil as a fuel. Concentration of hazardous contaminants modelled represent the 90th percentile of over 400 samples of waste oil. (Ref 1).

Table 5.4-10 used the data in Tables 5.4-4 and 6 to determine ambient air impact of non-threshold contaminants from a single source burning waste oil. Metal emission at 75% and 97% DRE are assumed.

The ambient air impact can be loosely related with associated cancer risks (Refer to Table 5.4-11). No analysis was done for chlorinated organics and solvents in samples from Hay River. The occurrence of the organics in waste oil collected at Hay River is expected to be very low.

TABLE 5.4-10 AMBIENT AIR IMPACT FOR "NON-THRESHOLD" METALS AND CHLORINATED ORGANICS

NON-THRESHOLD CONTAMINANT	CONCENTRATION IN FEED		STACK HEIGHT		
			10 m	15 m	20 m
Ambient Air Concentrations (ug/m ³)					
Arsenic	16	ppm	0.003	0.001	<0.001
Cadmium	4.0	ppm	<0.001	<0.001	<0.001
Chromium	28	ppm	0.005	0.002	0.001
Benzene	160	ppm	<0.001	<0.001	<0.001
Carbon tetrachloride					
PCB's	50	ppm	<0.001	<0.001	<0.001
Tetrachloro- ethylene	1200	ppm	0.008	0.004	0.001
Trichloro- ethylene	1049	ppm	0.007	0.003	0.001
1,1, 2- Trichloroethane	1300	ppm	0.007	0.004	0.001

See Table 3.8-8 for the waste oil feed parameters.

TABLE 5.4-11 LIFETIME CANCER RISK ASSOCIATED WITH
WASTE OIL BURNING IN AN URBAN AREA

		Airborne Annual Concentra- tion (ug/m ³)	Cancer Risk	Approximate Risk to an Individual
Arsenic	a	0.0050	2.0×10^{-5}	1:50,000
	b	0.0033	1.3×10^{-5}	1:77,000
		0.0016	6.4×10^{-6}	1:156,000
Benzene	a	0.0018	2.7×10^{-8}	1:37,000,000
	b	0.0006	8.9×10^{-9}	1:110,000,000
Cadmium	a	0.001	1.9×10^{-6}	1:530,000
	b	0.0007	1.3×10^{-6}	1:760,000
Chromium		0.0086	1.1×10^{-4}	1:9,100
		0.0057	7.1×10^{-5}	1:14,000
Carbon Tetrachloride		0.0122	4.5×10^{-7}	1:2,200,000
		0.0041	1.5×10^{-7}	1:6,600,000
PCB's		0.0006	7.4×10^{-7}	1:1,300,000
		0.0002	2.5×10^{-7}	1:4,000,000
Tetrachloro- ethylene		0.0147	2.2×10^{-7}	1:4,500,000
		0.0049	7.4×10^{-8}	1:13,000,000
Trichloro- ethylene		0.0128	4.6×10^{-8}	1:22,000,000
		0.0043	1.5×10^{-8}	1:65,000,000
1,1,2-Tri- chloroethane		0.158	2.6×10^{-7}	1:3,800,000
		0.0053	8.7×10^{-8}	1:12,000,000

Source: (Ref. 1 Table 5-2, 5-3)

a assumes 97% destruction removal efficiency for organics and 75% of the metals in the feed stock are emitted.

b assumes 99% DRE, 50% metals emission.

5.5 STANDARDS AND REGULATIONS

Emissions from the facility should comply with the desirable range of quality in the Canada Clean Air Act, Ambient Air Quality Objectives (Ref. 6). Range of quality may be designated as desirable, acceptable or tolerable. See Table 5.5-1.

Secondary Lead Smelter Regulations from the Clean Air Act indicate that:

- 1) particulate matter shall not exceed 0.046 (0.023) grams per normal cubic metre, dry and undiluted. The two values 0.046 and 0.023 gm/m³ are for different types of operations.
- 2) Concentration of lead in the particulate matter is not to exceed 63% by weight.

The suggested ground level concentration limits for lead emissions are:

24 hour, not to exceed 5 ug/m³
30 day, not to exceed 2 ug/m³

TABLE 5.5-1

Air Contaminant	Concentrations	Range of Quality
Sulphur Dioxide	a) 0 to 30 micrograms per cubic metre annual arithmetic mean b) 0 to 150 micrograms per cubic metre average concentration over a 24 hour period c) 0 to 450 micrograms per cubic metre average concentration over a one hour period	DESIRABLE
Sulphur Dioxide	a) 30 to 60 micrograms per cubic metre annual arithmetic mean b) 150 to 300 micrograms per cubic metre average concentration over a 24 hour period c) 450 to 900 micrograms per cubic metre average concentration over a one hour period	ACCEPTABLE
Sulphur Dioxide	300 to 800 micrograms per cubic metre average concentration over a continuous 24 hour period	TOLERABLE
Suspended particulate matter	0 to 60 micrograms per cubic metre annual geometric mean	DESIRABLE
Suspended particulate	a) 60 to 70 micrograms per cubic metre annual geometric mean b) 0 to 120 micrograms per cubic metre average concentration over a 24 hour period	ACCEPTABLE
Suspended particulate	120 to 400 micrograms per cubic metre average concentration over a continuous 24 hour period	TOLERABLE
Carbon monoxide	a) 0 to 6 milligrams per cubic metre average concentration over an 8 hour period b) 0 to 15 milligrams per cubic metre average concentration over a one hour period	DESIRABLE

TABLE 5.5-1 (Continued)

Air Contaminant	Concentrations	Range of Quality
Carbon monoxide	a) 6 to 15 milligrams per cubic metre average concentration over an 8 hour period b) 15 to 35 milligrams per cubic metre average concentration over a one hour period	ACCEPTABLE
Carbon monoxide	15 to 20 milligrams per cubic metre average concentration over a continuous 8 hour period	TOLERABLE
Nitrogen Dioxide	0 to 60 micrograms per cubic metre annual arithmetic mean	DESIRABLE
Nitrogen Dioxide	a) 0 to 100 micrograms per cubic metre annual arithmetic mean b) 0 to 200 micrograms per cubic metre average concentration over a 24 hour period c) 0 to 400 micrograms per cubic metre average concentration over a one hour period	ACCEPTABLE
Nitrogen Dioxide	a) 400 to 1,000 micrograms per cubic metre average concentration over a continuous one hour period b) 200 to 300 micrograms per cubic metre average concentration over a continuous 24 hour period	TOLERABLE

6.0 HAZARDOUS WASTES

6.1 GENERAL

There are currently no federal or territorial regulations defining hazardous wastes and/or approved disposal methods. Federal regulations are forthcoming; they will affect the collection, transport, storage and disposal of both used oils and contaminated fuels. The federal act is currently in draft form and will not be enacted until 1986 at the earliest.

The act will affect all producers and users of waste oil. Exemptions may be made for operations which recycle the hazardous waste. Rerefining of used lube oils is a recycling process as the lubricating quality of the oil is reclaimed. Burning waste oils for heat recovery might be considered a recycling process as the heating quality of the oil is reclaimed. Use of used oils for dust suppression on roads is not usually considered to be recycling, since both the lubricating and heat qualities of the oil are lost.

When the act is in place, waiver or relaxation of regulations is critical for the collection and storage of waste oil at Hay River. Hazardous waste regulations may prohibit the mixing of hazardous wastes from individual sources, regardless of similarities of source and type of wastes. Collection costs at Hay River would increase significantly, as each volume of waste to be collected would require separate collection, independent of the volume. It is very reasonable to assume that this regulation can be waived in Hay River, given the nature of the intended operation.

It is possible that waste oil processing residues (decanted waste water, centrifugal solids) and combustion residue (ash) will also be classified as hazardous wastes. Sampling and analysis for concentration of hazardous contaminants in the residues would

likely be required. No exemptions from hazardous waste regulations are likely to be made for hazardous residues from recycling operations. Disposal in an environmentally safe manner would be required.

6.2 DEFINITION OF HAZARDOUS WASTE

The chemical, physical/chemical and biochemical characteristics of waste material determine the hazardous nature. The wastes may be toxic to man or they may have a low flashpoint which is potentially hazardous to man and property. In 1980, a report (Ref. 3) on hazardous wastes in northern and western Canada was commissioned by Environment Canada, the governments of the four western provinces and Ontario, and the two territorial governments. In the report, a hazardous waste is defined as:

"any refuse or discarded material or combination of refuse and discarded materials which cannot be safely and adequately handled by existing waste management facilities because they pose a substantial, present or potential, hazard to human health or other living organisms or the physical environment because of their chemical, biological or physical properties." (Ref.3)

The report characterizes hazardous wastes in seven categories:

- 1) ignitable
- 2) corrosive
- 3) reactive
- 4) toxic
- 5) infectious
- 6) bio-accumulative
- 7) mutagenic, carcinogenic, and teratogenic.

A waste displaying one or more of these characteristics is classified by its primary hazard.

6.3 WASTE CATEGORIES

The Reid Crowther Report (Ref. 3) identifies 40 hazardous waste categories; seven of the categories will or may be associated with a waste oil collection system at Hay River.

PCB Fluids and Contaminated Materials - Waste Type 1

The materials are hazardous because of potential toxicity, bioaccumulation and mutagenic characteristics. Polychlorinated biphenyls are associated with electricity production, distribution and use. The local power company, Northland Utilities (NWT) Ltd., has indicated there is no PCB equipment in the Hay River area.

The federal government maintains an inventory of askerols (pure PCB's) and have indicated no PCB's exist in the Hay River area. The possibility of PCB contamination of the waste oil collected at Hay River is considered extremely low. Monitoring for PCB's may be required and is outlined in section 8.7.

Oils - Waste Type 2

Oils are considered hazardous because of their high volumes created, ignitability and potential toxicity.

Solvents - Waste Type 3 (Halogenated), Waste type 4 (Non - halogenated), Waste Type 5 (solvents in heavy metals).

These are hazardous due to ignitability and toxicity. Solvent wastes result from metal cleaning and degreasing (heavy equipment repair), printing and drycleaning operations. Low volumes of solvents are expected at Hay River.

Sludges - Sludge residue from oil processing is classified by reference 3 as waste type 35 - Tank Bottoms.

Tank Bottoms - Waste Type 35

These are hazardous because of toxicity. Tank bottoms incorporate sludges and residues which accumulate in storage tanks.

Fly Ash - Waste Type 38

Residue from burning fuel contains metals and other inorganics. Ash is hazardous due to toxicity.

The wastes can be further separated on the basis of high and low priority waste. High priority wastes are high hazard (PCB's), high volume (oils, solvents) or bioaccumulative (PCB's). Low priority wastes are relatively low volume (tank bottoms) or low hazard (fly ash).

6.4 WASTE MANAGEMENT

There are 15 waste management categories (A-0) identified in the Reid Crowther report. The categories are based on applicable treatment and disposal systems. The waste management categories discussed here are suitable for disposal of wastes which would be associated with the proposed facility at Hay River. The disposal systems most suited for application at Hay River are highlighted.

Recovery System: A - Oils (waste type 2)

B - Solvents (waste type 3,4,5)

Waste oil can be reclaimed (solids and water removal only) or re-refined (removal of solids and water, contaminants acquired during use and original additives). Reclaimed and rerefined oils can be used as fuel or as lubricants. Reclaiming and re-refining of used oils are discussed in sections 8.3 and 11.4, respectively.

Solvents can be recovered by distillation or extraction for re-use as a solvent, or fuel. There are insufficient volumes of solvents at Hay River for this to be considered as a disposal practice.

Thermal Destruction D: PCB's, Oils, Solvents (all types),
Tank Bottoms

Incineration is the most common destruction method for organic wastes. Incineration is a controlled combustion process. The organics are oxidized to water and CO₂. The inorganic residue (ash) may contain heavy metals.

Physical-Chemical E: volume reduction of aqueous wastes (oils)

F: dewatering of sludges (fly ash, eg.
from scrubber)

Filtration uses a filter medium for separation of solids (particulates) from the liquid stream. Filtration systems are also available for oil/water separation. The filter residue and removed water may require further processing. Secure landfill may be required for hazardous constituents in the solid residue.

Evaporation and distillation are used for volume reduction (eg. removal of water) and concentration of hazardous constituents to facilitate further treatment or disposal. In distillation, an attempt can be made to separate and recover vapour components.

Evaporation may be carried out by three different methods. In each case energy is applied to the liquid:

- 1) Contained heating medium: the heating medium is separated from the liquid by a physical barrier (e.g. coils, jackets, tubes)
- 2) Direct contact medium: e.g. steam sparging
- 3) Solar: evaporating pond.

Evaporating ponds can be used only in arid environments. The evaporation rate must exceed the annual rainfall and the volume of the pond must be sufficient to contain the waste and rainfall. Water and volatile contaminants are vapourized. The less volatile contaminants and salts remain behind. The pond may be periodically cleaned, and the sludge residue is disposed of in a secure landfill.

Environmental risks of evaporating ponds include surface water and subsurface contamination. Noxious and/or toxic vapours may also occur.

Secure Landfill I: tank bottoms, fly ash

A secure landfill is distinguished from a dump in that the landfill is an engineered, controlled operation, posing minimal threat to the environment. At Hay River, secure landfill may be achieved by containment of wastes in drums. Drums should be segregated from municipal wastes to minimize environmental risk.

Records of hazardous wastes and location of the waste are maintained in a secure landfill. Hazardous wastes may be retrieved from the landfill for economic gain (e.g. recovery of oil from sludge) or for permanent disposal when destruction facilities are available (eg. incineration of PCB's).

Deep Well Injection K: waste waters, sludges (occassionally)

Liquid wastes are injected into a suitably deep geological formation. Safe operation of the well relies on the ability of the formation to contain the waste.

The most significant environmental risk of deepwell injection is the contamination of ground water due to failure. The failure may be mechanical - due to poor well completion techniques, cracked or fractured pump casings, liners or tubing seals. The failure may also be geological with vertical or lateral migration of the waste.

A major failing of injection systems is due to the reduction or loss of formation permeability as a result of the waste injection: physical plugging, biological action (growth of bacteria, fungii, microorganisms), chemical precipitation as a result of chemical reactions between the waste and the host rock or reservoir fluid.

Wastes which are disposed of in deepwells are usually chemically

treated prior to injection. All wastes must be 'compatible' with each other and with the formation.

Land Treatment M: sludge farming (oils, tank bottoms)

Liquid wastes and dilute sludges are mixed with surface soils to promote volume reduction (through evaporation) and aerobic decomposition. Application rates are typically 4,000 - 7,000 litres per hectare. There is routine cultivation with disc or harrow. Total degradation of waste oils by the microbial population will occur within 6 months - 3 years. The action is enhanced by nutrient supply, aerobic conditioning and climatic conditions. An impermeable soil base will prevent ground water contamination through leaching. Environmental risks include surface water contamination, odours and destruction of site vegetation.

7.0 CONCEPT FOR A WASTE OIL FIRED WATER HEATING SYSTEM

7.1 GENERAL

The municipal water supply for the Town of Hay River is drawn from Great Slave Lake. The intake pumphouse is located on the south shore of the lake, 3 miles north of the Town. The actual lake water intake is located towards the center of the lake, approximately 5 miles from shore. At the pumphouse raw water is treated with chlorine injection and pumped to the Town.

During the winter months, the temperature of the lake falls to 0 - +0.5°C. The lake water must be heated at the intake pumphouse to avoid freezing in the transmission line. The existing heating system uses No. 1 light fuel oil (eg. diesel). As an alternative, waste oil collected at Hay River can be used as a fuel, with a potential significant saving to the Town. The use of waste oil as a fuel has its own limitations, as contaminants found in waste oil present serious technical and operating problems (increased emissions, fouling and corrosion of boiler tubes, deposits, etc.) Design of a waste oil fired heating system must provide for these limitations. The design concept for a waste oil fired heating system at Hay River (Section 7.6), is planned to minimize the effects of the contaminants in the waste oil.

Operating and maintenance requirements were considered high priority for two reasons:

- 1) savings in fuel cost could not be negated by increased operating and maintenance costs.
- 2) If the operating and maintenance requirements are excessive, the waste oil fired system would be abandoned in favour of the heating system in place which uses virgin fuel.

Pre-treatment of the waste oil for removal of solids and water was judged to be essential for a waste oil fired facility at Hay River. The majority of the technical and operational problems associated with burning waste oil are directly attributable to solids and water contamination (eg. nozzle clogging, flameout). The actual pre-treatment system recommended is described in Section 8.4.

Soluble contaminants will not be removed by the pre-treatment process and will continue to contribute to formation of ash. Corrosion and fouling of heat transfer surfaces, deposit on boiler walls and particulate emissions will also continue to be problems. Design of the waste oil fired heating system at Hay River attempts to accommodate these problems and to minimize the effects.

The variance in fuel properties of waste oil collected at Hay River was also assigned high priority. The proposed system must be capable of handling a wide range of fuel types. The waste oil will vary from very low viscosity (contaminated fuels) to very high viscosity (used lube oils). Mixing and blending during collection and storage is recommended but may not be sufficient to ensure consistent fuel viscosity to the burner. The sources and types of waste oil collected and the ratios of contaminated fuels to used oils will vary from year to year. The viscosity of waste oil cannot be typified for this type of system. Design must allow for the 'worst' case to ensure operation of the system.

Emissions from the system were the third priority area in the design concept. Lead is the emission of most concern. Fortunately, the incidence of waste oils with lead contamination (ie. automotive) is very low, ie. less than 10% of the total volume of waste oil generated. Pre-treatment of waste oil for removal of solids and water will reduce the concentration of hazardous contaminants (lead, chlorine, etc.) in the waste oil, and therefore reduce the potential emissions. There were no

burners or boilers identified in literature as being capable of reducing emissions. The system in this section emphasizes operating and maintenance factors. Emission control is thought to be best effected through waste management and pre-treatment of waste oil.

The waste oil fired heating system proposed here closely approximates the existing system. The capacities of the system are equivalent (4.6×10^6 BTU/hr or 1347 kw), and full modulation (zero load through night, full load during day) has been provided. The existing heat exchanger system for heating of the town water is utilized.

7.2 DESCRIPTION OF SITE

The municipal water pumphouse is located on the south shore of Great Slave Lake approximately 3 miles north of the MacKenzie Highway and the Town of Hay River. The land is owned by the Town. Road access to the pumphouse is through airport boundaries. The road is maintained by the Town.

The pumphouse is located on the edge of the northern approach to Hay River Airport. If required, a stack of 40 feet or 12 metres (equivalent to tree canopy height) has been approved by the Federal Ministry of Transport. The major concern is that the stack may interfere with the Instrument Landing System (due east of the pumphouse). MOT also wish to be consulted regarding emissions and the effects on visibility. In opposition, the Canadian Environmental Protection Service have suggested that a stack height equal to two times the building height or two times the tree canopy height, (or 24 m) may be required in order to prevent flue gas downwash effects.

A fishing community of approximately 100 people is located one kilometre east of the pumphouse, across West Channel. There are no other residents near the facility. A public beach east of the pumphouse is rarely used. Preferred usage is the beach on Vale Island.

The pumphouse building is approximately 12 m by 12 m. Roof height is 7.0 m (23 feet). It is located approximately 200 feet from shore and is 5.5 m (18 feet) above the lake. Spring flood conditions reduce the distance to shore to 15 m. The area is heavily forested with a tree canopy of 12 m.

7.3 OPERATING REQUIREMENTS OF HEATING SYSTEM

Water Demand

Water demand ranges from 0.8-1.5 million litres per day. Average demand is 0.9 million litres per day.

The demand is not constant through the day, as night time requirements are very low. The operating day is estimated to be 16 hours.

There are two reservoirs for town water: The underground pump-house with a 4.5 million litre capacity and the mainland pumphouse with a 2.75 million litre capacity. Only the underground pumphouse is used during the winter. The mainland pumphouse is emptied.

Forecast for Future Population Growth & Water Demand

The population of Hay River was estimated to be 3200 in 1984. No real growth in population has been noted for five years. Events which would affect the population growth are:

- 1) installation of a proposed egg producing facility
- 2) polar gas project
- 3) extension of natural gas distribution network to Hay River
- 4) sale of NTCL

The Town of Hay River is making no growth projections and assumes a static population.

On the basis of a static population, no increase in water demand is forecasted. The existing system is estimated to be operating only 16 hours per day, and water production can be increased 50% with 24 hour operation if demand warrants. The proposed waste oil burning system will be of comparable size to the existing

facility; and can also be expected to meet a 50% increase in demand.

Heating Requirements

Heating of the Town water begins when the lake temperature drops to 1°C, and continues through the winter until breakup and the lake temperature increases to 1°C. The season is December to April, approximately 150 days.

At the pumphouse the water is heated from 0°C to 9°C. The water temperature in the underground pumphouse in Town is constant at 4°C. This is sufficient to prevent frost or freezing in the supply lines in Town.

Maximum Energy Requirement =

$$\frac{1,500,000 \text{ litres/day}}{16 \text{ hrs/day}} \times \frac{4.185 \text{ kJ}}{\text{kg}^\circ\text{C}} \times (9-0)^\circ\text{C} \times \frac{1 \text{ kg}}{1 \text{ ltr}}$$

$$\begin{aligned} &= 3.53 \text{ gigajoules/hr} = 3.53 \times 10^9 \text{ joules/hr} \\ &= 980 \text{ kw} \end{aligned}$$

The boiler is also used to heat the pumphouse building. This space heating is assumed to be .001 GJ/hr. If boiler efficiency is assumed to be 80%, required boiler capacity is:

$$\frac{980 \text{ kw}}{80\%} = 1225 \text{ kw}$$

Fuel Requirements

Fuel usage in the existing facility is not metered but was estimated by the Town to be 1000 litres per day. No. 1 fuel oil with a heat value of 140,000 Btu/imp. gallon (30.8 MJ/l) is used.

The total fuel used through the 150 day heating season is approximately 275,000 litres. Fuel storage is a 90,000 litre half underground tank. A 200 litre day tank is located inside the building, and preheats the fuel prior to burning.

The cost of fuel for the 1983-84 heating system was 28.9 cents/litre (\$1.30/gallon). The total heating cost was approximately \$80,000. In 1984-85, the fuel price was higher (35 cents/litre), and the estimated total heating cost is approximately \$96,000.

Water Treatment

The only water treatment for the town water is chlorine injection at the pumphouse discharge. There are tentative plans for the addition of a fluoride injection system.

At spring break-up and at other times, the lake water is extremely muddy. Particulate is highly visible in the town water. Simple settling (in a raw water reservoir) or an active water treatment plant are being considered as processes to alleviate this problem.

7.4 DESCRIPTION OF EQUIPMENT IN EXISTING SYSTEM

The existing heating system is shown in Figure 7.4-1. Raw water is drawn from the lake, heated and pumped to underground storage in Town.

The raw water system is isolated from the boiler. Hot water from the boiler passes through the an exchanger and returns to the boiler. Raw water is heated in the exchanger.

Boilers

Two boilers are in place at the pumphouse:

1) Cleaver Brooks Water Tube Boiler

M4W-3000, series 100

Maximum output	2,400,000 BTU/hr. (703 kw)
Input Maximum	21.4 US gph (81 litres/hr)
Input high	15.0 US gph (56.8 litres/hr)

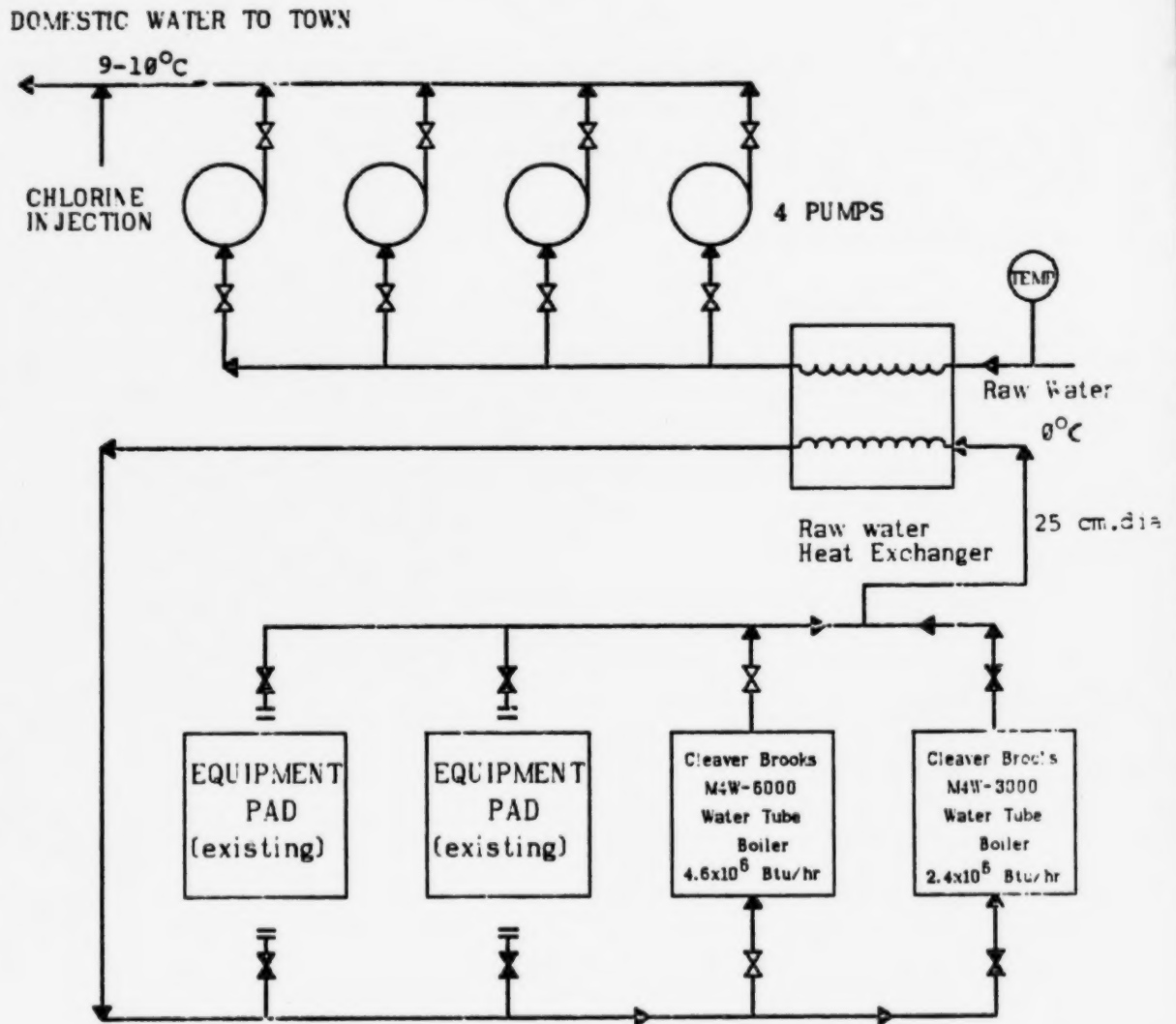
2) Cleaver Brooks Water Tube Boiler

M4-6000, series 100

Maximum output	4,680,000 Btu/hr. (1371 kw)
Input maximum	42.8 US gph (162 litres/hr)
Input high	27.5 US gph (104 litres/hr)

Only the large boiler is used to heat the Town water supply. In theory, the smaller boiler is a stand-by unit and has rarely been used. The small boiler is used during late fall and early winter to heat the pumphouse building before the main boiler is turned on.

The large boiler is operated on a demand basis throughout the day. The operation runs continuously throughout the heating season (December through April).



- NOTES
- 1) Spare equipment pads are existing. lines are run, valved and flanged.
 - 2) Cut outs in roof for extra chimney are in place and blanked out.

FIGURE 7.4-1 EXISTING HEATING SYSTEM AT HAY RIVER INTAKE PUMP HOUSE

There are two spare equipment pads, with valved and blind flanged inlets and supply manifolds for additional boilers. There are cutouts in the roof for chimneys.

Control System

A Modicon 484 controller is in place at the pumphouse. All equipment in the pumphouse is on the controllers except the pumps. The pumps would shut down at night due to zero demand.

The computer monitors raw water temperature at the heat exchanger inlet and commands boiler operation.

There is excess capacity on the controller. Controls and monitoring points for the proposed waste oil burning facility can be added to the controller.

Combustion Air

Combustion air inlet dampers are controlled by the Modicon controller.

Operating and Maintenance Staff

There is no full time operator for the present facility. Normally the pumphouse is checked twice a day. During the winter months a night watchman is hired and the operation is checked 4 times a day.

Operating and Maintenance Costs

The approximate annual cost of the water system is given below:

power:	\$100,000 (includes pumping water and sewage)
fuel:	\$100,000 (for heating of water at pumphouses only)
labour:	\$ 10,000 (includes up to 4 people, 10% of total salaries \$104,000)

Installation of a waste oil fired heating system will reduce the operating and maintenance costs for the pumphouse. Actual savings would be the difference between the price of virgin fuel (approximately \$100,000) and the operating and maintenance cost associated with the waste oilheating system. These costs are incremental to O & M costs of the existing facility.

7.5 MODIFICATIONS TO EXISTING BOILER

Modifications to the existing Cleaver Brooks Series 100 Boiler were examined as an alternative to a new boiler. The installation of a second burner to burn waste oil in the boiler was uncertain due to the tight packing of the tubes. A second factor was the potential fouling of the tubes. The unit is a water tube boiler, and the dense packing of the tubes would hinder tube exterior cleaning. The second row of tubes in the boiler were considered inaccessible for cleaning.

The existing boiler is to be left in place as a stand-by unit. If for any reason the waste oil heating system must be shut down during the heating season, the original boiler will need to be put into service to satisfy the heating requirements. The Town water must be heated through the winter months, as the transmission line to Town is not deep enough to avoid freezing.

7.6 PROPOSED WASTE OIL FIRED HEATING SYSTEM FOR HAY RIVER

The proposed waste oil fired heating system for heating the municipal water at Hay River is shown in Figure 7.6-1. The major components are the fire tube boiler and rotary cup burner. These units have been selected to minimize the effects of contaminants in the waste oil.

In the fire tube boiler, combustion gases flow through the tubes, and deposits will occur on the interior surface of the tubes. Cleaning the tubes and removal of ash is facilitated. A 150 hp (1470 kw or 5 MBTU/hr) Series M unit by Volcano Inc. has been selected. This is the smallest unit in the Series M design.

The rotary cup burner has been selected because of its suitability to burning waste oil. A wide range of viscosities can be atomized by the burner. Firing rates can also vary from zero to high loading. Manufacturer of the burner may be Hamworthy (Great Britain) or Saacke (Germany). The costs are equivalent.

An 180" x 71" (457 cm x 180 cm) boiler pad is required. There are two existing pads in the pumphouse which will have to be modified to make the pad for the fire-tube boiler. Overall dimensions of the boiler are 212" x 80" (538 cm x 203 cm).

The boiler is supplied as a complete package, including burner, fuel pump, controls, etc.

The fuel pump requires constant back pressure. A circulating pump will provide this requirement and will provide mixing of the fuel in the storage tank(s). (see figure 7.6-1)

A 3-way control valve for boiler water by-pass at the heat exchanger is also required. The temperature in the boiler is to be maintained at 200°F (93°C). Boiler water flows to the heat

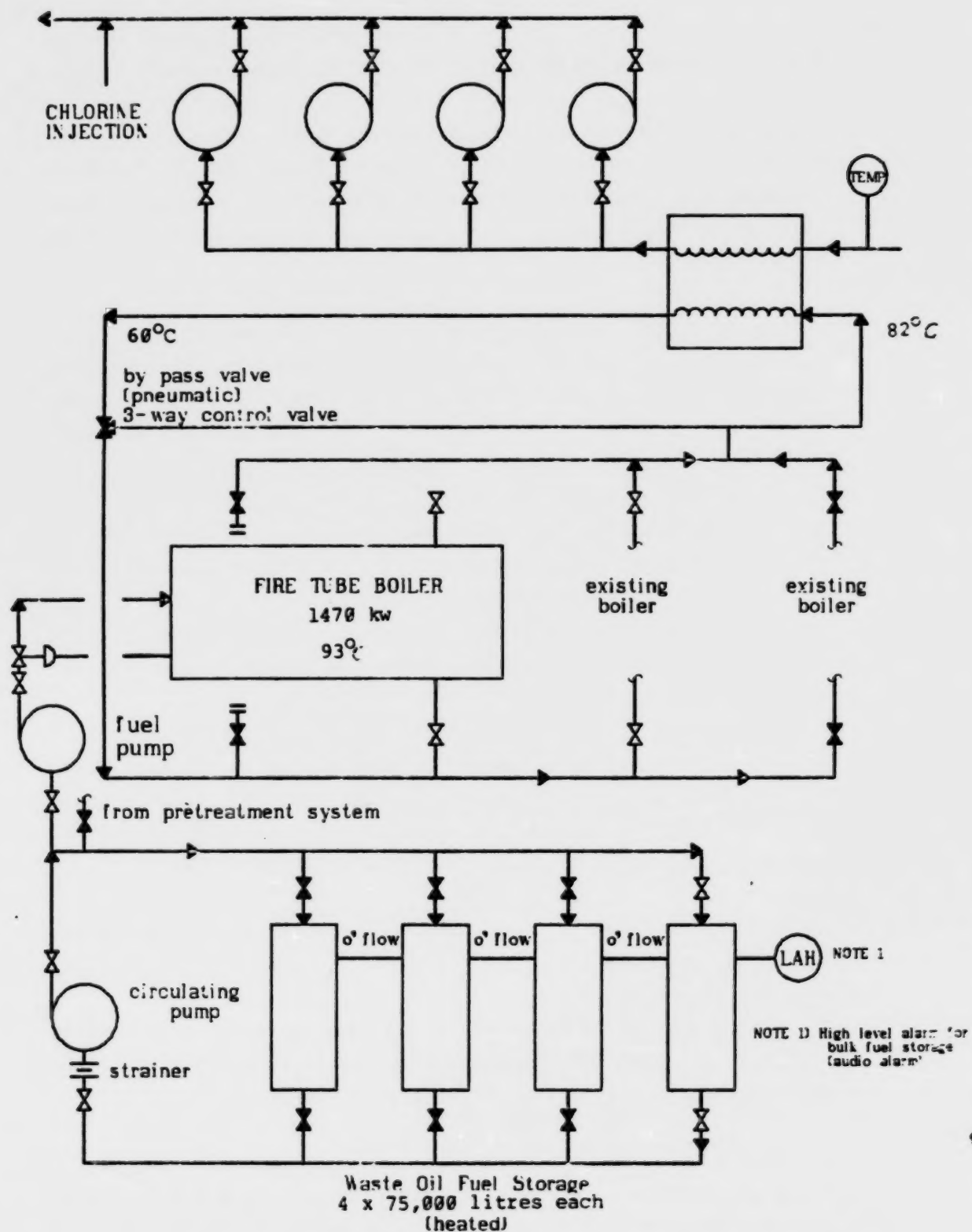


FIGURE 7.6-1

PROPOSED WASTE OIL FIRED HEATING SYSTEM FOR
HAY RIVER INTAKE PUMP HOUSE

exchanger at a temperature of 180°F (82°C), returns to the boiler at 140°F (60°C). A glycol heat exchanger is not recommended for use with a fire-tube boiler.

The strainer at the circulating pump suction is for protection of the pump and the rotary cup burner which is sensitive to solids.

An in-line heater is used to heat the fuel for ease of atomization. Fuel storage tanks are heated (when in use) to ensure the fuel is pumpable.

The circulating pump is used for mixing of fuel in storage. Thermal mixing (from heated tanks and from in-line heater) will assist in mixing. A consistent fuel blend to the burner is desirable.

All piping is to be welded joints. Air leaks from screwed or flanged joints will cause oscillations in the fuel feed to the burner. If the boiler is initially installed as a pilot plant operation, screwed joints which can be welded later are acceptable.

Stack

A stack height of 40' (12 m) has been approved by the Ministry of Transport. This is equivalent to the tree canopy height in the area surrounding the pumphouse. Permission for a higher stack would have to be obtained from MOT.

As noted in section 7.2, a 24 m stack may be required for adequate dispersion of the flue gas in the atmosphere.

7.7 MONITORING FOR EMISSIONS

The pre-treatment system described in Section 8.4 has been designed for maximum removal of solids and water from the waste oil fuel. This was considered necessary to minimize both operational problems and environmental impact (i.e. airborne emissions). All solids not dissolved in the fuel are removed during the pre-treatment process. Inorganics which are soluble in the fuel remain in the boiler as ash or are emitted in the flue gas.

There have been no attempts to predict the emissions from the facility. There are too many variables in the pre-treatment system: effect of demulsifiers, contaminated fuels, etc. Another variable which must be considered is the source and types of waste oils available at Hay River. At best, there is no reason to expect ground level concentrations of hazardous contaminants to exceed the desirable limits set out in the 'Clean Air Act' (federal) or by other provincial regulations (Section 5.5).

There is no pollution control equipment specified in the waste oil fired heating system design.

Monitoring Program

Environment Canada is interested in monitoring emissions from the plant as a basis for setting standards for similar operations in the north. Presently, there are no guidelines for emissions from this type of facility. Emissions for secondary lead smelter are the closest existing guidelines.

The monitoring program is visualized as a single, brief program, conducted over a two-three week interval. Monitoring would be for contaminants (organics and heavy metals) in fuel, stack gas and ground level concentrations. Residues (ash, oily waste water

and centrifugal solids) and untreated fuel should also be analyzed for hazardous contaminants. A suitable disposal method for each residue should be selected on the basis of potential risk to the environment.

The testing program may be financially supported by the Environment Protection Service (EPS) of Environment Canada. Private consultants who are capable of doing the testing include: Beak Consultants (Calgary, Vancouver); Hardy and Associates (Edmonton); Chemex, or Western Research - Division of Bow Valley Industries (both of Calgary).

The minimum cost of sampling and analysis is estimated at \$50,000, with sampling and analysis each accounting for 50% of this amount. Costs will increase with the number of contaminants chosen for monitoring.

Two approaches can be taken for the monitoring program:

- 1) testing for known contaminants which are of particular concern (heavy metals, organics, halide acids); and
- 2) a blind test wherein samples for everything are obtained, then analyzed for what is present in the sample.

The second approach would be far more costly than the first method, especially the analysis costs.

Because the facility is a small operation, and because it is a single source in a remote area, concentration of contaminants in the emissions may not be easily measured (since no 'background' presence of the contaminant exists in the air to contribute to the minimum detectable levels by sensors.) Reasonable detection limits for contaminants should be chosen.

PCB's and Organics

Before testing for PCB's in the stack gas and emissions, the fuel itself should be tested for PCB contamination. If PCB contamination is present, the emissions could be tested for destruction removal efficiencies.

Formation of dioxins may be of concern. Again, the unit is small and the detection limit may have to be extremely low to determine dioxin formation. If monitoring for dioxins is done, fuel should be analyzed for dioxins and precursors present.

8.0 COLLECTION AND PRE-TREATMENT OF WASTE OIL

8.1 GENERAL

Collection, pre-treatment and storage of the waste oil fuel are necessary support systems for the waste oil boiler. Unlike virgin fuel, waste oil fuel cannot be supplied on a demand basis. The waste oil must be collected when available. The fuel is required during winter months, when low ambient temperatures restrict the collection of waste oil. The waste oil will have to be collected, treated and stored prior to the heating season. Bulk storage must be provided for 100% of fuel requirements for the heating season. To ensure fluidity of the fuel, storage tanks must be heated.

Waste oils at Hay River may be highly viscous (e.g. Bunker C) or they may have a high pour point (one sample from Hay River had a pour point of +3°C). Warm ambient temperatures are required for the collection of waste oil. As semi-annual collection periods are required, spring and fall operation is indicated.

In the following sections, the collection, pre-treatment and storage systems are discussed. Disposal of residues is also discussed. The pre-treatment system will produce residues of oily waste water and centrifugal solids (sludge). The residues are of concern due to potential toxicity. Uncontrolled disposal of residues may provide a significant risk to the environment. Boiler ash is also a residue of concern.

The major factors to consider for disposal of residues are the volume and the hazardous nature of the residue. Neither factor is known in relation to residues at Hay River. In this report it is assumed that controlled disposal is required. At a later date, when more information about the residues is known, this disposal method can be reviewed.

8.2 WASTE OIL COLLECTION SYSTEM

The Town of Hay River has indicated that they do not want to operate a waste oil collection system, and would prefer to contract the collection system to private business. It is recommended that the Town retain "ownership" of the collection system and therefore the oil. Cost of collection would be the responsibility of the Town, and potential revenue from the sale of excess used lube oil to rerefinerries (Edmonton, Calgary, Vancouver) could support the cost of collection.

At least two companies in Hay River have the capabilities to handle waste oil: Hay River Disposal and Bassett Trucking. Many businesses already use Hay River Disposal for removal of waste oil to the dump, town collection tank or for delivery of contaminated fuel to MOT at the airport. Bassett Trucking has collected used oil from Northland Utilities and ATL, for transport and sale to the Turbo Refinery at Edmonton.

Storage capacity at the waste oil producer's site is critical in the waste oil collection system. Insufficient storage will require frequent collection of small volumes on a demand basis and result in increased collection costs. Storage should be adequately sized to ensure economic collection on a regular schedule.

At Hay River, semi-annual collection of oil is adequate for most producers. Table 2.5-1 shows the annual generation rates and the waste oil storage facilities of the companies surveyed at Hay River. (Not all producers of waste oil were identified and contacted during the survey). Most firms surveyed have storage equivalent to six months production or more. The collection periods will be determined by ambient temperatures, as waste oil is more easily pumped when warm. NTCL, ATL and Northland Utilities have peak waste oil generation times during spring and fall. All other firms surveyed indicated steady generation.

Ideally, all producers would have in excess of six months storage capacity, relieving the need for collection on a demand basis. Drums and used tanks are readily available at Hay River and can be used where existing storage is insufficient.

R. Angus, Merv Townsend Trucking and Stan Dean & Sons Construction reportedly have inadequate storage capacity. The first two firms have indicated no storage capability for used oil, the third company is presently using drums for a large volume (8200 litres) of used oil. All other sources contacted were assessed as having adequate or near adequate storage. Drums can be used to make up any deficiency. On-site storage capacity is the responsibility of the waste oil producer.

There is a 15,000 gallon (60,000 litre) tank in place at the Town yard. The tank should be made available to generators of used oil who wish to dispose of oil prior to collection. 'Do-it-yourselfers' could also access the tank for disposal of used oil. A separate fenced area in the town yard should be designated for drum storage, as producers of used oil using drums storage may not wish to have drums accumulate on their premises.

Collection of used oil from the marine transport companies would have to be on a demand basis. Both NTCL and ATL generate virtually all their waste oil during the shipping season (May - October). At spring break-up, large volumes of slops are available as the barges are emptied of old product and put into service. Used oil and contaminated fuels are available throughout the season. ATL has indicated a preference for collection of used oil directly from drums prior to offloading from barges. It is assumed that at least until their bulk lube oil handling system is in place, the same collection system would be preferred by NTCL. Collection of used oil from the barges would then be on a demand basis rather than a regularly scheduled service. The barge companies already have the capability to handle contaminated fuels, and collection of the fuel need not be

on a demand basis. Regularly scheduled collection service may be sufficient.

Collection of the waste oil would fall under the requirements of the Canadian Transport Commission Regulations for the transportation of flammable and combustible materials. Placarding of the collection vehicle may also be required under the proposed federal legislation for hazardous wastes.

Manifest System

If waste oil is designated a hazardous waste and no exemption is made for this facility (Section 6.0), then a manifest for the transport of waste oil may be required by Federal law. The manifest system would limit multiple collections of waste oil and increase collection costs. A sample manifest is shown in Figure 8.2-1.

PRESS HARD.

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INSTRUCTIONS ON BACK

Instructions au verso / Dactylographier ou écrire en lettres moulées

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graphier ou écrire en lettres moulées

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MANIFEST - MANIFESTE

CONSIGNEUR (GENERATOR) EXPEDITEUR
 Company Name: NOM DE L'EXPEDITEUR
 Address: ADRESSE
 City: VILLE
 Country: PAYS

CARRIER TRANSPORTEUR
 Company Name: NOM DU TRANSPORTEUR
 Address: ADRESSE
 City: VILLE
 Country: PAYS

CONSIGNEE (RECIPIENT) DESTINAIRE
 Company Name: NOM DU DESTINAIRE
 Address: ADRESSE
 City: VILLE
 Country: PAYS

Product Identification No. (Classification of goods)
 Product: PRODUIT
 Classification: CLASSIFICATION

Quantity Shipped (Quantité expédiée)
 Quantity: QUANTITE
 Unit: UNITE

Permitting Agency (Permis)
 Agency: AGENCE
 Permit: PERMIS

Origin of Goods (Origine des marchandises)
 Origin: ORIGINE
 Country: PAYS

Destination (Destination)
 Destination: DESTINATION
 Country: PAYS

Incoterms (Incoterms)
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 Signature: SIGNATURE

Signature of Carrier (Signature du Transporteur)
 Signature: SIGNATURE

Signature of Consignee (Signature du Destinataire)
 Signature: SIGNATURE

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 Declaration: DECLARATION

Declaration of Carrier (Déclaration du Transporteur)
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Declaration of Consignee (Déclaration du Destinataire)
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MANIFEST FOR TRANSPORT OF HAZARDOUS WASTE:

8.3 PRE-TREATMENT OF WASTE OIL, TECHNOLOGY

8.3.1 General

This section briefly reviews technology for reclaiming waste oils (summarized from references 4,9,12,18,20,21). The pre-treatment system for application at Hay River should provide for maximum removal of solids and water. The recommended concept is given in Section 8.4.

Solids and water removal is required for alleviation of technical and operational problems of burning waste oil. The technical problems associated with storage, transport and burning of used oil are:

- stratification in storage
- fuel line freezing
- burner flame-out
- inconsistent heat value
- burner and pump erosion
- line strainer plugging
- storage tank sludge build-up

There are two levels of treatment of waste oils. Minor processing, for removal of free water and solids, involves in-line filtering and gravity separation (settling and decanting). Major processing utilizes a tertiary device to further improve oil quality.

Minor Processing

Minor processing for solids and water removal will alleviate some of the technical problems described above. At the simplest level, the collected oil is allowed to settle for natural separation of oil and free water. Decanting involves draining the tank of the water layer. Over time, coarse solids will settle in a sludge at the bottom of the tank.

The waste oil may be heated to enhance separation of the oil and

water phases. Viscosity will also decrease, resulting in better settling of coarse solids and improved handling characteristics. A demulsifier can be added to the waste oil prior to settling, again to enhance oil/water separation. The demulsifier will break emulsions of bound water. (Section 8.3.3)

Minor processing will not significantly decrease the content of solubles and sub-micron sized contaminants in the waste oil. These contaminants contribute to scaling of the heat transfer surfaces, ash formation and particulate emissions. Virtually all trace metal contaminants in the fuel are soluble or sub-micron sized.

Major Processing

Major processing will further alleviate the technical problems associated with transport and combustion of waste oil. An active treatment device is utilized to further increase oil quality.

Distillation: will evaporate light fuel fractions and water from fuel. Hydrocarbons are collected and evaporated water vapour is released to the atmosphere. No solids removal is effected.

Filter Screens, Centrifuges: can be used for separation of fine solids from the fuel. The centrifuge can also be used for oil/water separation.

Agitators: used to mix emulsion breaking chemicals in lubricating oils. Demulsifiers will enhance removal of water and suspended solids.

At Hay River a good separation of oil, water and solids is desired. A two stage system can be used, e.g. distillation for removal of water and filter screens for removal of solids. Alternatively, centrifuging for removal of solids and water will be effective.

8.3.2 Centrifuging

Centrifugal force is essentially the same force as gravity, but several orders of magnitude greater. The force is applied simultaneously in all directions from the centre of rotation. The effect of applying centrifugal force to waste oil is to remove water and fine solids not removed in gravity settling.

Water occurring as free water (eg. washdown water, precipitation) will separate during gravity settling. Water acquired during the service life of the oil by atmospheric breathing, condensation, leakage of steam or cooling water will be emulsified with the oil. Dispersants and detergent agents are added to lubricating oil to promote emulsification. Other contaminants are also caught up in the emulsion (eg. carbon formed in an internal combustion engine; sludge created by partial oxidation of the oil; some wear materials). The contaminants exist as discrete particles or phases (ie. are not dissolved in the oil) and usually have a significantly different density than the oil. Centrifuging accelerates the separation of two or more phases where there is a difference in density between the phases. (Ref. 17)

Heating of the fuel prior to centrifuging will enhance the difference in densities of the oil and water phase. Heating will not affect the density of the insolubles, so separation of solids is also enhanced.

8.3.3 Demulsifiers

Natural settling and decanting will effectively remove free water and coarse solids from the oil. Bound water and suspended solids (including wear metals, soot) remain in the oil, due to the addition of dispersants and detergents to the original additives.

Dispersants are added to oils operated under light-duty, short trip, stop-and-go conditions, or where the engine rarely reaches normal operating temperature (eg. automotive). Sludge is formed during this type of service, along with a complex mixture of combustion products, water, carbon, soot, oxidated oil, etc., which are not soluble in the oil. The dispersants act to keep the particulates in suspension and prevent the formation of sludge. Detergents, used in high temperature engine oils, act in a similar manner to prevent deposits forming in the engine.

The addition of a demulsifier to the waste oil will act to break the action of the dispersants and detergents, and effect the removal of bound water and aid in the removal of suspended and inorganic solids. Agitation of the demulsifier and waste oil is recommended.

The demulsifier will not act to remove organic metals in solution (eg. Tetraethyl lead from gasoline contamination).

In the oil exploration and production fields, demulsifiers are added to slops tanks to enhance settling. Rates of addition are 1000 - 5000 ppm (0.1-0.5%). Turbo Refinery at Edmonton uses demulsifiers in the dehydraters, for enhanced water removal. Application rates are 1000 ppm (0.1%).

Esso Breaxit 8211 is the demulsifier recommended by Turbo Resources. Cost of the agent is approximately \$3/litre. For an addition rate of 0.1%, 275 litres would be required to treat 275,000 litres of fuel at a cost of \$825. Cost per litre of fuel is 0.3 cents/ litre. The volume of the collected waste is increased by water contamination. For 25% water content in collected waste, the gross annual waste oil volume required at Hay River would be 344,000 litres. The demulsifier requirement (@ 0.1%) would be 344 litres, at an approximate cost of \$1,030, or 0.38 cents/litre; an increase of 27%.

8.3.4 Removal of Solubles

Some contaminants, whether acquired during use or occurring as original additives to the oil are soluble in the oil. As solubles, they will not be removed by minor or major treatment processes. These contaminants contribute to corrosion and scaling of heat transfer surfaces. Virtually all trace metals which are of environmental concern (lead, cadmium, arsenic, zinc, chromium, barium) are soluble in oil.

Diesel engine lubricants have been mixed with diesel fuel to effect precipitation of some metallic salts. These salts are then removed with filtering and the oil can be burned as a fuel in diesel engines.

The addition of contaminated fuels to the used oil at Hay River may have a similar effect. The additions of demulsifier and agitation may increase the effect.

Other processes are available which effectively remove all contaminants (eg. solvent extraction, vacuum distillation). Adverse environmental effects and technical impacts of burning waste oil are then eliminated. These processes are equivalent to re-refining (section 11), and produce large quantities of waste residues which require secure landfill or further processing.

8.4 Pre-Treatment System for Collected Waste Oil

The proposed pre-treatment and storage system in the Hay River Waste Oil facility is shown in Figure 8.4-1. The previously discussed processes are incorporated in the concept. Pre-treatment of waste oil for removal of solids and water was judged to be essential for several reasons:

- 1) Alleviation of technical problems associated with burning waste oil.
- 2) Cost of fuel storage is high (minimum \$1.00 per gallon), removal of water from fuel will maximize the use of storage.
- 3) Alleviation of formation of sludge and tank bottoms during storage, and the necessity to clean storage tanks.

The pre-treatment system will be operated during the collection periods (spring and fall). It has been configured for maximum removal of water and solids. Mixing of different types of oils and contaminated fuels will also take place within the pre-treatment system. Maximum blending of the fuel prior to storage will produce a consistent fuel to the boiler.

The components of the pre-treatment system are:

1. Two front end holding tanks, each 30,000 litre capacity. Both tanks are heated.
2. Waste water residue (30,000 litres) and sludge residue (8,000 litres) tanks. Sludge tank is 'mud tank' design, open top required to receive centrifugal solids.
3. Centrifuge, used equipment, 2,000 litres per hour capacity, manual cleaning assumed.
4. Transfer pumps, (3), capacity compatible with centrifuge.
5. Dual basket filters (2)
6. In line electric heater, 3 kw. capacity
7. Trash strainer at receiving tank inlet.

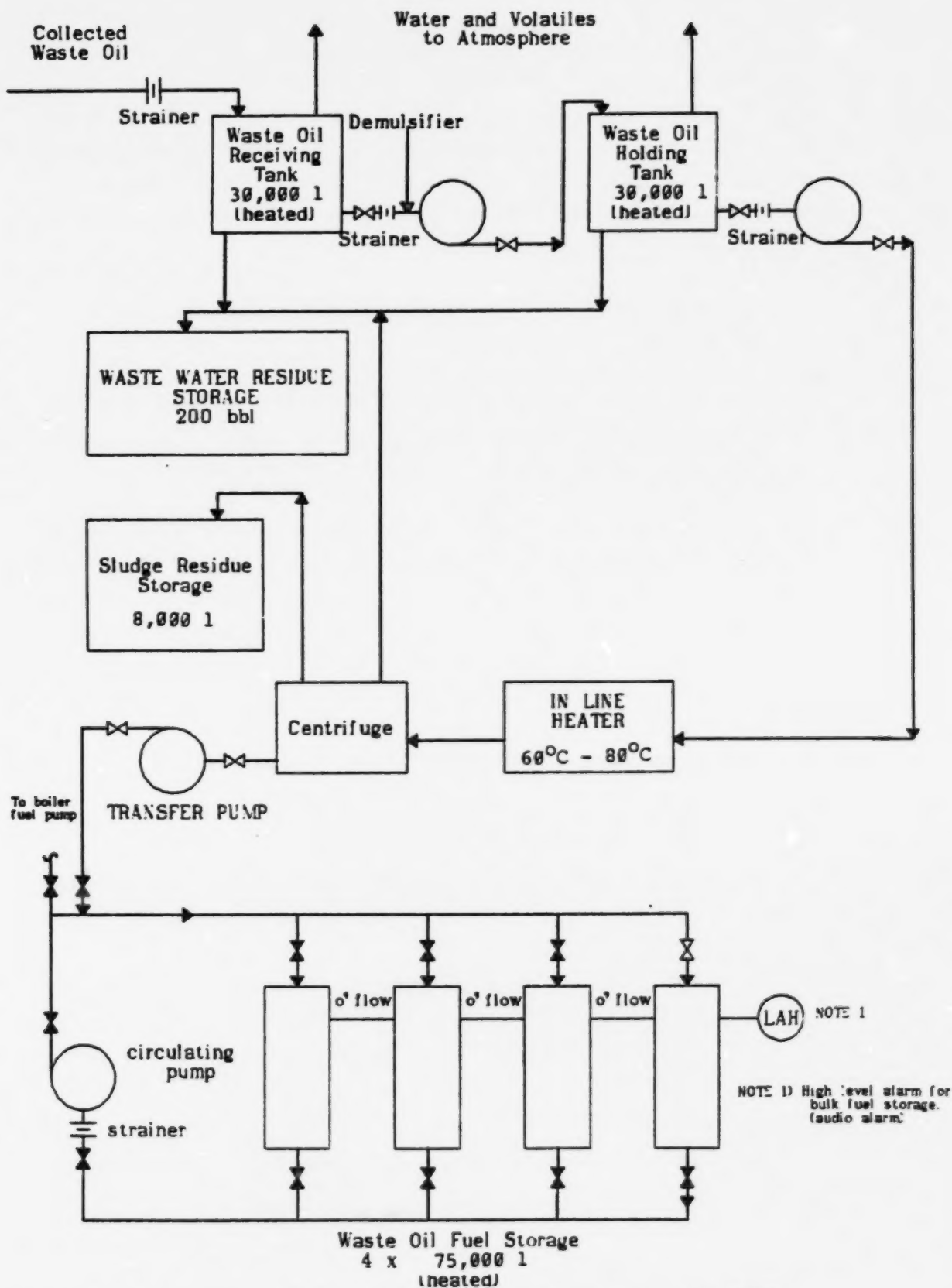


FIGURE 8.4-1

PROPOSED PRE-TREATMENT SYSTEM FOR WASTE OIL FUEL

Collected waste oil is transferred to a 30,000 litre receiving tank. This volume is meant to be 2 collected loads from a collection vehicle. The holding tank is the same volume as the receiving tank. Mixing of different types of fuels will occur in the two tanks.

Both tanks are heated for enhanced separation of water and removal of volatiles. The demulsifier should be added to the receiving tank. Agitation will be provided by the flow of collected oil into the receiving tank, and by the pumps. The holding tank has a baffle below the inlet to lessen disturbance of the oil/water interface. Water is drained from both tanks regularly, and stored separately prior to disposal.

A heater or heat exchanger will be required to preheat the oil prior to centrifuging. Fluid density will affect the throughput and effectiveness of the centrifuge. For the size and type of unit suggested here, fuel with a gravity of 35°API (density = .849 kg/l) will have a throughput of 2,000 litres/hour. For a gravity of 20°API (.933 kg/l) throughput is reduced to 1,000 litres/hour. The density of waste oil is typically 20°API at 60°F. (For comparison, API gravity of diesel fuel is 53°). With the heater, the density of the fuel can be maintained at 35-40°API (.849-.824 kg/l). The heater can also be used during the operating season, as heating the fuel to the boiler will reduce fuel viscosity and improve atomization of the fuel.

The heat exchanger and the heating coils in the holding and receiving tank may utilize waste heat from the pump house if the boiler is still in use. The alternative is to use electric heating coils which are more easily maintained.

The major component of the pre-treatment system is the centrifuge. If properly maintained and operated it is capable of complete removal of solids and water from the fuel. Two types of centrifuges are available: an automatic desludging unit which is

self-cleaning and a manual cleaning unit which requires two hours maintenance every 8-12 hours operation. The cost of the automatic desludging machine (>\$100,000) was judged to be too high for the limited use (100-150 hours/year). A manual machine was also considered to be expensive (\$30-\$50,000) but feasible. A used machine was considered the most viable with an approximate cost of \$15,000.

A monitor for the centrifuge system is available at a cost of \$6,000. The monitor will shut down the system if the centrifuge solids chamber within the unit is full. The system would require checking every 3-4 hours with the monitor. Without the monitor, the system would require checking every half hour, i.e. a full time attendant.

Maintenance requirements on the centrifuge are approximately two hours per day for cleaning. A full time operator of the pre-treatment system is recommended. The operator would be able to check the centrifuge and the system regularly and perform maintenance. The collection periods are estimated to be 10-12 days each, during spring and fall.

Operating requirements of the pre-treatment system can be reduced by a larger front end tank system with only one pre-treatment period annually. Oil collected during spring can be allowed to settle during summer months. Water can be drained regularly prior to the fall pre-treatment.

8.5 STORAGE OF WASTE OIL AT PUMP HOUSE

The estimated fuel requirements for the proposed system at Hay River are 275,000 litres per year. The actual requirements will vary from year to year depending on water demand in Town. The recommended storage volume is 10% excess over estimated requirements, 300,000 litres. Four tanks of 75,000 litres capacity each will meet storage requirements.

Tanks are to be installed above ground. Each tank is electrically heated (wire wrapped) and insulated. Heating is required to ensure the fuel is pumpable. Only one tank will require heating at any time (exception is at change over). A pump is used to recirculate fuel through the tank. The boiler fuel pump is supplied from the recirculating line. An in-line heater (3 kw) is used to heat the fuel to a temperature which is suitable to the operation of the burner. Recirculation and thermal mixing will prevent separation of wastes in storage and provide a consistent fuel blend to the boiler.

Other tank configurations are possible. Above ground tanks were selected because of lower purchase cost and lower installation costs. Above ground tanks also have a higher salvage value. Larger tanks (eg. two 150,000 litre tanks) will likely have a lower total capital cost. Heating and mixing the larger volume will increase operating costs. Smaller tanks may have a larger capital cost and will require a larger storage site. Operating costs would be lower due to ease of mixing and heating of smaller volumes.

Used tanks have been identified as being available near Hay River. Lloyd Brunes, Superintendent for the Town has indicated 12 tanks along the MacKenzie River. A battery of 8 tanks, 60-100,000 litres each is located at Camsell Bend, 10 kilometres off the ice road. The tanks are of the bolted type and are not suitable for virgin fuel storage. Gulf Oil, the owner, have

indicated to Mr. Brunes they have no further use for the tanks. The eight tanks are on skids, for ready transport. The tanks would have to be collected, cleaned and inspected, and heat tracing and insulation added. Tanks not used for pre-treatment waste oil storage could be used for the receiving tank, holding tank and waste water tank.

The storage facilities for waste oil must conform to the National Fire Code-Section 4: Regulation of Petroleum Products, Storage, Use and Handling. This code regulates tank design, tank layout and ancillary piping, dyking of storage areas, etc. In addition, tank specifications must conform to the GNWT Petroleum Products Ordinance.

The GNWT guidelines for bulk fuel storage recommend overflow alarms on fuel storage tanks. Most fuel spills in the NWT within the past 10 years were reportedly due to overflow. A high level alarm and overflow connections are recommended. The alarm will alert the operator of the pre-treatment system that the storage is full.

Layout of tanks will be according to the National Fire Code. Dyking of the area is required to contain spills and to prevent leakage to other areas. The dyke should enclose the greater volume of:

- 1) 110% capacity of the largest tank
- 2) 100% of the largest tank plus 10% of the combined volume of all other tanks.

It is probable that the receiving tank, holding tank and residue tanks would also be located within the storage tank area. These tank volumes should be included in the calculation of volume to be dyked. Recommendations for site selection, preparation and dyke construction are contained in GNWT guidelines for bulk fuel storage.

Other forms of heating may also be used, including an immersion heater or hot water coils for the tanks, or hot water heat exchanger for the in line heater. Hot water heating would use waste heat off the boiler. The capital costs of wirewrapping and immersion heaters are approximately the same for this application. Wire wrapping was selected because of lower maintenance requirements, and the tank can be heated in sections (eg. bottom third only if tank is half full). This sectional heating will result in lower operating costs.

8.6 DISPOSAL OF RESIDUES

As yet there are no federal or territorial ordinances regulating the disposal of oil processing residues. The residues for consideration are water and sludge (including sludge, tank bottoms and centrifugal solids). The combustion process will also yield an ash residue which must be disposed. In the future, these residues will possibly be designated hazardous wastes, and will require disposal in an environmentally safe manner. Disposal methods for hazardous wastes are described in Section 6.4.

The selection of a disposal method for a residue considers two criteria:

- 1) volume of residue for disposal
- 2) hazardous nature of the residue

The potential threat to the environment resulting from various disposal methods can then be assessed.

Neither the volume or nature of the residues can be determined prior to installation of the facility at Hay River. Assumptions made in order to choose a disposal method are:

Waste water residue is equivalent to 20% by volume of collected waste oil (eg. 69,000 litres). Disposal is by deepwell injection in northern Alberta (Rainbow Lake or Zama area).

Sludge residue is equivalent to 1% by volume of collected waste oil (eg. 3,400 litres). Disposal is by sludge farming at Norman Wells, N.W.T.

Boiler ash residue is assumed to be low hazard. Disposal is at Hay River landfill.

For waste water and sludge residue, a disposal fee (\$5/bbl or \$31/m³) and transportation charges (\$3 - \$6/bbl or \$19-\$38/m³) are included in the operating and maintenance costs of the facility (Section 9.3). Storage for the residues which are generated during the pre-treatment process has also been provided in the system design (Section 7.6).

The following discussion considers each of the three residues and examines possible disposal methods.

Waste Water Residue

Water separated from the waste oil will have a residual concentration of oil. Chlorinated and aromatic solvents are soluble in both oil and water, and tend to concentrate more in the water. The oil-soluble metals remaining in the oil after pre-treatment are not soluble in water, and low concentrations of trace metals in wastewater may remain due to the residual oil.

Current practice for disposing of waste water has been identified in several locations as "dumping at source". At Dome Petroleum Tuktoyaktuk base, the water decanted from waste oil is discharged directly to Tuktoyaktuk Harbour or evaporated in front of the Saacke burner. In the Beaufort Sea, water decanted from waste oil on board ships is filtered for removal of oil and discharged into the ocean.

In Alberta, deepwell injection at an approved site is used for disposal of waste water from oil production and crude oil reclaiming operations. The water may also be evaporated (incinerated or in an evaporation pond). The disposal method used at Hay River will depend on the degree of contamination of the wastewater. There are several deepwell injection sites in the Zama and Rainbow Lake areas which could be accessed from Hay River. These wells are used for disposal of salt water from oil production, and the operators may not wish to use the well for

disposal of oily wastewater. There was formerly a well at High Level which was used for disposal of residues from crude oil reclaiming. The well has been shut down as it was not being properly operated. When the well is opened again, it can be used for disposal of the water from Hay River. A charge for disposal is made by the operator; usually at least \$5.00/barrel (or \$31/m³) of waste.

Sampling and analysis of wastewater for concentration of hazardous contaminants is recommended. A suitable disposal method can then be selected with certainty. The volume of wastewater for disposal is not known at this time. The volume will affect the disposal method selected. For this analysis 20% water in collected waste oil is assumed. The volume of wastewater for disposal is therefore 69,000 litres.

Sludge Residue

Centrifugal solids, sludge and tank bottoms differ in their method of production. Centrifugal solids are removed from the waste oil during pre-treatment. Sludge is generated rapidly as part of the normal layering associated with settling. Tank bottoms are the thick tar-like layer which forms slowly over a period of months or years. Sludge residue may not occur if the tank is pumped dry. Similarly, tank bottoms may not be generated if the tanks are cleaned. The collective sludge mixture will consist of sedimentary materials and residual oil. Metals removed from the waste oil during pre-treatment will be concentrated in the centrifugal solids. The material is considered highly toxic but relatively low volume. (e.g. 1% of 300,000 litres = 3,000 litres per year). Recognized disposal methods for these residues include secure landfill, incineration, sludge farming and deep well injection.

If deepwell injection is available, it is the most direct method of disposal available. The cost is low (3,000 l/yr x \$31/m³ =

\$930/yr), not including transportation. It is possible that the oil companies operating the disposal wells in the Zama and Rainbow Lake areas may not wish to accept sludge residue for disposal. The sedimentary nature of the sludge could clog up the wells which have been designed for water disposal only. The well at High Level is better suited to sludge disposal if an operator can be found.

Secure landfill might consist of storing the sludge in drums and containment in a secure area at the dump or pumphouse. The cost is low for this type of disposal but the effectiveness is questionable. Leakage from the drums is possible, and the containment area should be secure (i.e. controlled).

Incineration of sludge in an incinerator and open pit have both been identified in the NWT. Installation of an incinerator for the small volume produced is costly. Open pit burning is a very messy procedure and produces clouds of black smoke. Contaminants in the sludge residue may not be destroyed in burning and are emitted directly to the atmosphere. High ground level concentrations may result.

Sludge farming is practised in Alberta and at Norman Wells for disposal of residues from oil refineries and crude oil reclaiming. This may be an attractive disposal method for disposal of sludge residue. Application rates for sludge farming are 4,000 - 7,000 litres per hectare. The volume of sludge at Hay River is estimated to be 3,000 litres. The land requirement is therefore 1 hectare. The small land requirement will facilitate site selection and the actual operation of spreading and cultivating. Alternatively, the sludge could be shipped to Norman Wells for sludge farming by Esso. Transportation cost and disposal cost would be incurred.

Sampling and analysis of the sludge residue for concentration of hazardous contaminants is recommended.

Boiler Ash

Ash from the combustion process will contain approximately 50% of the metals in the feed fuel. The balance of the metals are emitted to the atmosphere during combustion. The ash is toxic and secure landfill is the only recognized disposal method. At Hay River, secure landfill may require containment of ash in drums. The drums can be disposed of at the dump, preferably with the location noted in municipal records. Sampling and analysis of the ash residue for concentration of hazardous contaminants is recommended.

8.7 MONITORING FOR HAZARDOUS WASTE

The Environmental Protection Service have indicated concern for PCB contamination of the Waste Oil Collection system. While there are reportedly no PCB inventories at or near Hay River, there is a slight possibility of medium grade contamination in the area or PCB's being transferred from other areas to Hay River.

PCB's are usually associated with the electrical industry. An EPS source has suggested that transformer oils should be refused by the facility. The volume of transformer oils generated at Hay River is very small (100 litres per year). This volume is currently disposed of with other used oil generated by Northland Utilities. The transformer oil can be segregated from the waste for collection. An alternate disposal method has not been suggested.

A second suggestion from EPS was that a waiver indicating that the oil contains no PCB's (<1 ppm) be signed by the owner or producer of the waste. Small samples of the oil could be secured prior to bulk collection. The samples of oil could be tested for PCB contamination. If PCB's are found, the small samples would be analyzed to determine the source. Disposal of PCB contaminated waste (or fuel) would be the responsibility of the source.

PCB analysis is available from Envirotest Laboratories in Edmonton, at a cost of \$65.00/sample.

9.0 CAPITAL AND OPERATING AND MAINTENANCE COST

9.1 GENERAL

The capital, operating and maintenance costs of the waste oil heating system are described in Section 9.2 and 9.3. The heating system has been broken down into components: collection, pre-treatment, storage, boiler, and 'other services'.

The waste oil collection system is assumed to be contracted out to local business at Hay River. The town does not have the capability of collecting waste oil and have previously indicated their preference for a contracted collection system. The capital cost for the collection system is very low (\$4,300). It includes advertising, signage, and make-up storage if required. No allowance has been made for purchase of a collection vehicle by the town.

The pre-treatment system can be operated by the town or by local business. There is a high capital cost associated with the pre-treatment system, \$50,900 (Table 9.2-2), and the town will have to retain ownership of the system. The operating period is very short (30 - 40 days/year total) and operation of the system is assumed to be by the town, at a cost of \$25.00 per hour. The centrifuge has been specified as used equipment, all other equipment is assumed to be new. If used equipment, suitable to the application, is readily available, substantial savings could be made in the capital costs.

The tankage required for bulk waste oil fuel storage has an estimated cost of \$48,500 (including heat tracing, insulation, delivery, but not site preparation) for new tankage. If used tanks are available, they may be suitable. Consideration must then be given to the costs of recovery, cleaning and inspection, etc. If the tanks are not insulated and/or without heating

capability, these features must be added. The cost of reclaiming used tanks may soon exceed the cost of new tanks.

The operating and maintenance costs outlined in Section 9.3 are incremental to O & M costs for the existing systems. Labour requirements, residue disposal costs, etc. are based on conservative estimates. In Section 10.2, the effect of the conservative estimates is examined. For viability analysis, operation and maintenance costs determined here (\$23,000 annually) are used.

In Section 10.3, the consequences of payment to producers of waste oil are analysed. In the O & M costs determined here, there is no allowance made for payment of waste oil. A sufficient quantity of waste oil to meet the requirements of the heating system is assumed to be freely available.

Pilot Plant

A different approach to this project would have been to look at the installation of a pilot plant to determine the suitability of waste oil as a fuel.

In a pilot plant installation, the risk (technical or environmental) can be assessed. If the risk is considered to be too high (eg. technical failure, emissions of hazardous contaminants to the environment), the pilot plant is dismantled. Salvage value and dismantling costs are included in the original budget for the pilot plant project.

This approach has not been used for the proposed facility at Hay River. The technical and environmental risks have been identified. It was felt that a pilot plant installation was not necessary, as there is sufficient evidence in the literature to support the concept of a waste oil fired boiler.

Monitoring Plant

A program for monitoring hazardous emissions is included in the capital costs. The monitoring program can be carried out to determine the environmental impact of burning waste oil as a fuel. It is assumed that the program is developed under the guidance of Environmental Protection Service (Environment Canada). The results of the monitoring program will be used to set standards for similar installations in the north. Cost of the Monitoring Program is estimated to be \$50,000.

9.2 CAPITAL COSTS

9.2.1 General

The estimated capital costs for the system components (collection, pre-treatment, storage, boiler) are given in Table 9.2-1 through -5. The total capital cost is estimated to be \$312,100 - \$327,100 (Table 9.2-6). The range in price is due to a range in price for the centrifuge in the pre-treatment system (Table 9.2-2). The centrifuge is specified as used equipment. Actual cost of the unit will depend upon the selection and availability of used equipment at the time of purchase. All other equipment in the facility has been specified as new equipment.

In Sections 9.2.2 through 9.2.6, the requirements of each system component are discussed. The pre-treatment system, storage system and package boiler each represent approximately 20% of the total capital cost. Ancillary services (design, project management, supervision and training) and trades (piping, mechanical, electrical, structural, contracting, etc.) are given in Table 9.2-5, and represent 40% of the total capital cost.

All costs are F.O.B. Hay River, unless otherwise specified.

9.2.2 Collection of Waste Oil

A capital cost of \$4,300 has been allowed for the implementation of the waste oil collection system (Table 9.2-1). The amount is very approximate and includes advertising, signage and placarding, and additional storage capacity. The operation of the collection system will be contracted out to local business. The capital cost of a collection vehicle is not included, as the vehicle would be hired from a contractor at an hourly rate.

TABLE 9.2-1 CAPITAL COST - COLLECTION OF WASTE OIL

#	ITEM	COST
1	Signage and Placarding (allow)	\$ 800.00
2	Advertising (allow)	2,500.00
3	Storage (allow)	1,000.00
	TOTAL	\$ 4,300.00

Advertising is required to inform the public of the collection system, e.g. collection periods, who to contact for collection, types of waste to be collected, etc. Advertising should also advocate waste management practices by the producers, i.e. reduction of water and solids contamination in the waste oil generated.

Signage is required at the public disposal site (eg. Town yard). At the Town dump signage is required to advise the public to use the public disposal site. Placarding of the collection vehicle(s) may be required by federal law.

A sum of \$1,000 has been allowed for additional storage to that currently available. The extra capacity may be required at the Town yard or the dump. Either tanks or drums may be used.

9.2.3 Pre-Treatment System

A capital cost of \$50,900 - 65,900 has been allowed for the installation of the pre-treatment system (Table 9.2-2). The cost range varies due to the price of the centrifuge, estimated at \$15 - \$30,000 (depending on the availability of used equipment).

Operation of the pre-treatment system is planned during the

collection periods (spring and fall), and is estimated to be 20 - 24 days/year total. In section 9.3-2, Maintenance and Operating Costs, 40 days/year (2 periods of 20 days each) are allowed. The operating days are 8 hours. Total service of the pre-treatment system is 320 hours/year. This is a low usage factor for the centrifuge suggesting the installation of used equipment which will meet the requirements of the waste oil heating facility. A substantial reduction in capital costs may be realized.

The requirements of the system are as follows:

- o front end tankage (receiving tank, holding tank)
 - volumes should be 30,000 litres each or larger
 - heating capability is preferred on at least one tank (preferably the holding tank). Insulation is not essential, power costs will increase slightly during the operating periods (40 days total).
 - heating may be by electrical wire wrapping or immersion heater. For new tankage, the costs are approximately the same. The wire wrapping is lower maintenance and has been selected here (2 kilowatt). Waste heat from the boiler may also be utilized if boiler is in operation during the pre-treatment periods.
 - the high level alarm and overflow connection are recommended in GNWT guidelines for bulk fuel storage. Spills will be prevented.
- o Residue storage (wastewater residue tank, sludge residue tank) can be sized for each collection period:
 - wastewater tank should be minimum 30,000 l capacity (equivalent to almost half of total expected water content in the collected waste oil. Recall, it was assumed the waste oil would contain 20% water: 69,300 ltr. water and 275,000 ltr. fuel). The tank can be heated to evaporate water.
 - sludge residue tank volume of 8,000 litres is suitable. As the centrifugal solids are removed from the centrifuge manually, an open tank is required to receive the sludge.

TABLE 9.2-2 CAPITAL COST - PRE-TREATMENT SYSTEM

#	ITEM	COST
1	Waste Oil Recovery Tank and Waste Oil Holding Tank, each 30,000 l capacity. Price includes electrical heat tracing (2 kw) and insulation (2" urethane foam and sealer coat); manhole, nozzles, ladders and overflow connections; transportation to Hay River and set up at site.	\$13,100.00
2	High Level alarm for waste oil recovery tank and waste oil holding tank. Electric, audio alarm.	1,000.00
3	Waste water residue storage tank approximately 30,000 l capacity, including manhole, nozzles and ladder; transportation to Hay River and set up at site.	5,000.00
4	Sludge Residue Storage Tank 8-10,000 litre capacity, 'Mud Tank' design with open top, including transportation to Hay River and set up at site.	2,700.00
5	Centrifuge: make, model and capacity determined by availability of used equipment. 2,000 litre/hr throughput capacity.	15,000.00 to 30,000.00
6	3 transfer pumps, 1 each at receiving tank and holding tank discharge, 1 after centrifuge to bulk fuel storage. All pumps to be of same make, model and capacity. Capacity to be compatible with centrifuge volume throughput (Item 5.0). Price includes pads and motors.	3,600.00
7	2 strainers, dual basket type, 1 each at pump suction of receiving tank and holding tank discharge pumps	4,000.00
8	1 strainer for trash removal at receiving tank inlet	1,000.00
9	In-line electric heater (3 kw), capacity to be compatible with centrifuge (Item 5.0) and pumps (Items 6.0). Capable of heating waste oil from holding tank temperature (10 - 40°C) to 60 - 80°C	3,500.00
10	Shelter for centrifuge and pumps - erected on site	2,000.00
TOTAL		\$50,900.00 to \$65,900.00

- o Strainers are recommended at the pump suction for removal of coarse solids. This will reduce pump erosion and solids loading of the centrifuge. Dual basket type filters are indicated for ease of maintenance.
- o The in-line heater is not essential to the operation of the system. If viscosity of the waste oil is not lowered sufficiently in the holding tank, volume throughput of the centrifuge will be reduced.
 - a 3 kilowatt electric in line heater has been specified. A heat exchanger utilizing boiler heat is also suitable. Use of a heat exchanger requires that the boiler be in operation during the pre-treatment periods.
- o pumps should be suited to the service, in terms of viscosity range and solids loading (eg. sediment which causes pump erosion).
 - if possible, all pumps should be equivalent. Spare parts requirements are reduced.
 - pumping capacity should be equivalent to centrifuge throughput (2,000 l/hr)
 - the transfer pump after the centrifuge can be dual service; i.e., used during pre-treatment, and as the circulating pump during the heating season. This requires that the boiler not be in operation during the pre-treatment periods.

Sensitivity Considerations

The use of used equipment rather than the new equipment specified here will significantly affect the capital cost of the pre-treatment system. The front end and residue tankage represent a significant portion of the total capital cost of the pre-treatment system. (\$20,800 or 40%). The cost and availability of used tanks at Hay River have not been assessed. Used tanks would have to be reclaimed, cleaned and inspected. Heating capability is recommended for at least one tank (holding tank).

The centrifuge has already been specified as used equipment. Procurement of a unit at a low purchase price (i.e. \$15,000) will likely take several months. If used equipment is not available a

new unit (\$30-50,000) will be required.

9.2.4 Storage of Waste Oil Fuel

A capital cost of \$62,200 has been allowed for the bulk waste oil fuel storage system (Table 9.2-3). This amount includes site design and engineering for all tanks (including pre-treatment system tankage).

TABLE 9.2-3 CAPITAL COSTS - STORAGE OF WASTE OIL FUEL

#	ITEM	COST
1	4 fuel storage tanks, each 75,000 l capacity including electrical heat tracing (2 kw) and insulation (2" urethane foam and sealer coat); manhole, nozzles, ladder and overflow connections; transportation to Hay River and set up at site.	\$48,500.00
2	1 High level alarm for fuel storage tanks electric, audio alarm	1,000.00
3	1 circulating pump, make and model equivalent to Item 6, Table 9.2-2 price includes pad and motor	1,200.00
4	In-line electric heater (3 kw), equivalent to Item 8, Table 9.2-2	3,500.00
5	1 Dual basket strainer at circulating pump suction, equivalent to Item 7, Table 9.2-2,	2,000.00
6	Site engineering for storage tank area (allow)	2,000.00
7	Site preparation for storage tank are, including dyking (allow)	4,000.00
TOTAL		\$62,200.00

Above ground storage has been recommended over underground storage. The above ground tanks have a lower purchase price, lower installation cost and higher salvage value than underground tanks. The tanks require heating whether above or below ground. The insulation recommended for the tanks should be sufficient to minimize heat losses and ensure contained fuel is pumpable. Generally, only one tank is heated at any one time, the exception is during change-over.

The requirements of the system are as follows:

o Storage Tanks

- Total capacity should be in excess of 275,000 ltr.
 - Heating capability is required on all tanks. The heating may be electric wire wrapping or immersion heater. For new tankage, the costs are approximately the same. The wire wrapping is lower maintenance and has been selected here (2 kilowatts).
 - Wire wrapping may be done in 3 sections on the tanks, at an additional cost of \$100.00 per tank. This allows sectional heating of the tanks and would reduce operating costs.
 - All tanks should be insulated to minimize heat losses.
 - The high level alarm and overflow connections are for use during filling the tanks. The audio alarm will warn the pre-treatment system operator of possible overflow, and spills will be prevented. The alarm is recommended in GNWT guidelines for bulk fuel storage.
 - There is no low level alarm in the storage system. Operation of tanks in parallel, or visual inspection of tank volumes remaining will prevent cavitation of the pumps.
- o The circulating pump may be dual service, used as the centrifuge transfer pump during pre-treatment and as the circulating pump during operation of the boiler. This requires the boiler not be in operation during the pre-treatment periods.

- circulating pump is used to mix fuel in storage and provide a consistent blend to the burner. The pump should be capable of turning over the volume of 1 tank (75,000 l) in 24 hours or 52 l/min.

This is slightly larger capacity than the pumps specified in the pre-treatment system (40 lpm). It is recommended that all pumps be the same make and model, as this will reduce the required spare parts inventory.

- o The electric in-line heater (3 kilowatt) may be dual service - used in the pre-treatment system and during operation of the boiler. The heater is required to heat the fuel to the burner to provide a sufficiently low viscosity for atomization at the burner.

- waste heat from boiler could also be used for this service.

Sensitivity Considerations

As in the pre-treatment system, tankage represents a significant portion of the total capital cost of the storage system (\$48,500 or 78%). If used tanks are available they may be suitable for the installation. The tanks would have to be reclaimed, cleaned and inspected. Heating capability must be added to the tanks. If tanks are to be above ground, insulation is required, since heat losses would increase power costs. Installation costs and site engineering and preparation costs would increase if underground storage is selected.

9.2.5 Waste Oil Fired Heating System

A capital cost of \$67,200 has been allowed for the installation of the heating system (Table 9.2-4). The boiler package by Volcano is the major component of the system. A rotary cup burner by Saacke or Hamworthy is specified.

Sensitivity Considerations

The stack height of 12 m is assumed. The MOT has approved the height. If ground level concentrations are considered to be too high by EPS, a higher stack is required.

TABLE 9.2-4 CAPITAL COST - WASTE OIL FIRED HEATING SYSTEM

#	ITEM	COST
1	Package boiler by Volcano, Series M, 150 hp (1470 kw) fire tube boiler with rotary cup burner including boiler control system and fuel pump	\$62,000.00
2	3-way control valve for bypass circulation of the boiler water. Pneumatic type by Spartan or Valtex	1,200.00
3	12 metre Stack	2,500.00
4.	Placement of boiler, including breeching and stack	1,500.00
TOTAL		\$67,200.00

9.2.6 Other Capital Costs

In Table 9.2-5, the capital cost for electrical, mechanical and structural contractors, piping, etc. are given. All values are estimated and are based on the use of local expertise wherever possible.

All piping is to be welded. If the operation is built initially as a pilot plant then screwed fittings, capable of being welded, are acceptable. The welded fittings are critical on the feed line to the boiler fuel pump. Air leakage into the line will result in fuel oscillations at the burner, possibly causing burner flame-out or other problems.

TABLE 9.2-5 CAPITAL COSTS - OTHER

#	ITEM	COST
1	Detail engineering for complete facility (allow)	\$25,000.00
2	Project Management (allow)	12,000.00
3	Piping, for pre-treatment, storage and boiler system	25,000.00
4	Electrical contracting for pre-treatment, storage and boiler system.	5,000.00
5	Extension of 2 existing boiler pads to accommodate new boiler (assume no other modifications to pumphouse are necessary)	1,000.00
6	Tie-in of new equipment and controls to existing Modicon 484 controller.	5,000.00
7	Start up and commissioning, training and supervision of operating personnel.	5,000.00
8	Sampling and analysis for hazardous contaminants in fuel, emissions, residues. (by Environment Canada).	50,000.00
TOTAL		\$128,000.00

TABLE 9.2-6 CAPITAL COST - TOTAL

#	ITEM	COST
1	Collection of Waste Oil	\$ 4,300.00
2	Pre-Treatment System	50,900.00 to 65,900.00
3	Storage of Waste Oil Fuel	61,700.00
4	Waste Oil Fired Heating System	67,200.00
5	Other (including EPS monitoring program for hazardous contaminants)	128,000.00
TOTAL		\$312,100.00 to 327,100.00

9.3 OPERATING AND MAINTENANCE COSTS

9.3.1 General

The estimated operating and maintenance costs for the waste oil fired heating system and the associated systems are given in Table 9.3-1 through -5. The total O & M cost is estimated to be \$23,000 per year annually. This cost is incremental to the existing system operating and maintenance costs (Section 7.3).

In Sections 9.3.2 through 6, the O & M costs associated with each component of the facility are discussed. Approximately 50% of the costs are associated with the pre-treatment system. A further 25% of costs are associated with operation of the waste oil fired boiler. In both the pre-treatment and boiler systems, labour requirements are a significant portion of the costs (60% and 95%).

Manpower requirements in the two areas have been deliberately over assessed. Operators will be employed by the town rather than contracted (as for the waste oil collection system). Labour requirements presented here are estimated on the basis of maximum requirements.

Water contamination of waste oil is also a major factor in determination of operating and maintenance costs. Collection costs, pre-treatment costs (including dispersant), and residue disposal costs are all directly related to water content of the waste oil:

Fraction of Water Collected

	<u>@ 20% Water</u>	<u>@ 10% Water</u>	<u>Difference</u>
net oil collection cost	\$2,800	\$2,470	\$ 330
demulsifier	1,035	915	120
wastewater residue disposal @ \$50/m ³	3,440	1,520	1,920
	<u>\$7,275</u>	<u>\$4,905</u>	<u>\$2,370</u>

20% Water - 275,000 litres fuel + 69,000 litres water

10% Water - 275,000 litres fuel + 30,000 litres water

If the water content in collected waste oil is reduced from 20% to 10%, O & M costs are reduced by \$2,370. This is a reduction of 1/3 of the direct costs (collection, demulsifier disposal).

Power requirements are included in the operating and maintenance costs. Unit price of 6.5 cents/kwh is assumed.

9.3.2 Collection of Waste Oil

The collection costs in Table 9.3-1 are dependent on the following:

- 1) operating costs, \$50/hr. for the collection vehicle, \$15/hr. for the driver.
- 2) collection time is 1 hour for 50 bbl vehicle, 1.5 hours for 100 bbl vehicle. This allows for turnaround time at the pumphouse and a return trip to Town. Multiple stops for collection are also allowed for.
- 3) 20% water contamination is assumed in the collected waste oil.

Collection costs are estimated to be \$65/50 bbl or \$81/m³ (6,400 litres fuel and 1,600 litres water) or \$100/100 bbl or \$62.50/m³ (12,800 litres fuel and 3,200 litres water).

Sensitivity Considerations

A tender contract is likely to result in much lower collection costs. MOT indicated payment of \$40 for pick-up and delivery of 1700 gallons (8,000 litres) contaminated fuel (ie. 60% of the estimated collection cost of \$65).

Waste management by generators of waste oil will reduce the water contamination in the waste oil. Water contamination is assumed to be 20% initially. A collected load of 100 bbl (16,000 litres) is then comprised of 12,800 litres fuel and 3,200 litres water. A collection cost of \$100 is equivalent to $\$100/12,800$ litres or 0.78 cents/litre of fuel.

If waste management practices reduce water contamination to 10%, the same collected load would comprise 14,400 litres fuel and 1,600 litres water. The collection cost is then $\$100/14,400$ litres or 0.69 cents/litre, a reduction of 13%.

TABLE 9.3-1 OPERATING AND MAINTENANCE COSTS -
COLLECTION OF WASTE OIL

#	ITEM	COST (\$/year)
1	Collection Costs	
	Assume <u>\$65</u> for unit and driver hour	
	For 50 bbl collection vehicle, allow 1 hour for collection and delivery of waste oil to pre-treatment site (for 100 bbl collection vehicle, allow 1.5 hour)	
	$\frac{344,000 \text{ ltr.}^*}{\text{year}} \circ \frac{\text{bbl}}{160 \text{ ltr.}} \circ \frac{1 \text{ hour}}{50 \text{ bbl}} \circ \frac{\$65}{\text{hour}} = 2,795.$	\$ 2,800.00
	* equivalent to 275,000 litre fuel and 69,000 litre water (20% water contamination)	

9.3.3 Pre-Treatment System

The operating and maintenance costs for the pre-treatment system are given in Table 9.2-2.

A full-time operator is required during the pre-treatment periods. The centrifuge will require 2 hours maintenance daily for the removal of solids. At full capacity of 2,000 l/hour and a 6 hour operating day, the centrifuge would process 12,000 l/day. The total fuel requirement is 275,000 litres (60,000 gallons), indicating 23 days/year.

Allowances must be made for water contamination, extended maintenance and reduced capacity (eg. highly viscous fuels). Forty days operation have been allowed for in the estimate.

Sensitivity Considerations

The requirement for a full-time operator has been deliberately over-assessed at 40 working days. This is equivalent to 1 man-month during each of the spring and fall periods. It is quite possible that the fuel can be processed during a two week period, spring and fall. Costs are then reduced 50%.

The effectiveness of a demulsifier should be tested. The addition of the demulsifier is recommended to enhance solids and water separation. The presence of contaminated fuels and the heated tanks may be sufficient, with no added effect resulting from the demulsifier.

An allowance has been made for disposal of waste water and sludge residues. There are two factors to be considered:

- 1) volumes of residues are not known
- 2) hazardous nature of residues is not known

The waste water residue is assumed to be 20% by volume of collected waste oil, eg. 69,000 litres (430 bbl). Disposal by deepwell injection in northern Alberta is estimated to cost \$50/m³, including transportation. If the water can be disposed locally at Hay River (eg. clay pit at Town dump) costs are significantly reduced. Analysis of waste water for hazardous contaminants is recommended prior to selection of disposal method. Local disposal may be acceptable.

The volume of waste water requiring disposal will be significantly reduced by waste management by producers of waste oil. At 10% water contamination in collected waste oil, the waste water volume is only 30,000 litres. Disposal costs would be reduced to \$1,500 for 30,000 l, compared to \$3,440 as specified here.

Sludge residue is assumed to be 1% by volume of the collected waste oil, eg. 3,500 litres. This is reasonable, in consideration of the ash (ie. non combustible organics) content of samples of waste oil collected at Hay River (0.16 - 0.65%, by weight, Table 3.8-3). The density of the sludge is not known. Assume the volume is 3,000 litres or approximately 20 bbl. An allowance of \$70/m³ (\$11/bbl) has been made for disposal of the sludge at Norman Wells. Again, local disposal (ie. at clay pit in Town dump) may be possible. Analysis of the sludge for hazardous contaminants is recommended prior to selection of disposal method. Incineration of the sludge may also be possible.

TABLE 9.3-2 OPERATING AND MAINTENANCE COSTS -
PRE-TREATMENT SYSTEM

#	COST	COST (\$/year)
1	Full time operation during spring and fall collection periods. e.g. 40 days/year. (operation and maintenance of complete system, including centrifuge)	
	$\frac{40 \text{ days}}{\text{year}} \times \frac{8 \text{ hrs}}{\text{day}} \times \frac{\$25}{\text{hr.}} = \frac{8,000}{\text{year}}$	\$ 8,000.00
2	Demulsifier @ 0.1% addition, 20% water contamination:	
	$344,000 \times 0.001 = 344 \text{ ltr. emulsifier}$ @ \$3.00/ltr.	1,035.00
3	Waste water residue disposal, by deepwell injection (Northern Alberta)	
	allow \$5/bbl disposal charge allow \$3/bbl transportation charge to disposal site	
	$0.20 (344,000*) = 69,000 \text{ ltr. waste water}$ = 430 bbl @ \$8/bbl (\$50/m ³)	3,440.00
4	Sludge Residue Disposal (sludge farming at Norman Wells)	
	allow \$5/bbl disposal charge allow \$6/bbl transportation allow 1% by volume solids in collected waste oil	
	$0.01 \times 344,000 \text{ litre} = 3,440 \text{ litres solids}$ assume 20 barrels	220.00
5	Power (tank heating, pumps, centrifuge, inline heater) (40 operating days per year)	550.00
	TOTAL	\$13,200.00
	* equivalent to 275,000 litres fuel, and 69,000 litres water (i.e. 20% water contamination)	

9.3.4 Storage of Waste Oil Fuel

The only operating and maintenance cost associated with storage is power for pumping and heating (Table 9.3-3). The circulation pump and in-line heater will be operated continuously through the 150 day heating season. Only one of the four storage tanks will be heated at any one time except at change-over.

TABLE 9.3-3 OPERATING AND MAINTENANCE COSTS -
STORAGE OF WASTE OIL FUEL

#	COST	COST (\$/year)
1	Power - Tank heating, circulating pump, inline heater; 150 days per year	Allow \$ 1,300.00
	TOTAL	\$ 1,300.00

9.3.5 Waste Oil Fired Heating System

The operating and maintenance costs for operation of the waste oil fired heating system are given in Table 9.3.4. The maintenance requirements are:

- 1) clean out of fire tubes each week through the heating season
2 hrs/week x 22 weeks = 44 hours
- 2) cleaning of rotary cup burner, each day of the heating season
1 hr/day x 150 days = 150 hours

Sensitivity Considerations

The package boiler supplier has indicated much lower maintenance requirements:

- 1) clean out fire tubes once each month through the heating season
2 hrs/month x 5 months = 10 hours
- 2) clean the rotary cup burner once each week through the heating season, cleaning time = 0.5 hours.
0.5 hrs. x 22 weeks = 11 hours

The figures in Table 9.3-4 have been deliberately over-estimated. Initially the boiler operator may wish to clean the burner and tubes frequently, this will ensure efficient operation of the system. Gradually a maintenance program for the waste oil boiler at Hay River will be developed. Operating and maintenance requirements will be between those in Table 9.3-4 and those suggested by the manufacturer.

TABLE 9.3-4 OPERATING AND MAINTENANCE COSTS -
WASTE OIL FIRED HEATING SYSTEM

#	COST	COST (\$/year)
1	Checking and cleaning of rotary cup burner allow 1 hour/day, 150 days/year = 150 hrs/year @ \$25/hour	\$ 3,750.00
2	Removal of ash from boiler, clean out fire tubes allow 2 hrs/week, 22 weeks/year = 44hrs/year @ 25/hour	1,100.00
3	Ash disposal (landfill at Hay River) allow	250.00
TOTAL		\$ 5,100.00

9.3.6 Other Operating and Maintenance Costs

Sampling and analysis of the pre-treated fuel for concentrations of hazardous contaminants may be desirable. Results could be used to assure the public that the operation of the waste oil burner at the pumphouse does not pose a serious threat to the environment. There is no legal requirement that the fuel be tested. An allowance of \$600/year has been made for sampling and analysis of the fuel on an ongoing basis.

TABLE 9.3-5 OPERATING AND MAINTENANCE COSTS -
OTHER

#	COST	COST (\$/year)
1	Sampling and Analysis of Waste Oil Fuel for hazardous contaminants, including arsenic, barium, cadmium, chromium, lead, zinc, PCB's, and total chlorine	
	allow	\$ 600.00
	TOTAL	\$ 600.00

Sampling and analysis for hazardous constituents in the residues is also desirable. Residue disposal methods are selected on the basis of potential hazards to the environment. If low hazards can be demonstrated, a method with low cost can be used for disposal of residues.

TABLE 9.3-6 OPERATING AND MAINTENANCE COSTS -
TOTAL

#	COST	COST (\$/year)
1	Collection of Waste Oil	\$ 2,800.00
2	Pre-Treatment System	13,200.00
3	Storage of Waste Oil Fuel	1,300.00
4	Waste Oil Fired Heating System	5,100.00
5	Other	600.00
TOTAL		\$23,000.00

10.0 VIABILITY AND BENEFITS

10.1 VIABILITY

The technical viability of this project is sound, as has been discussed elsewhere in this report (Section 4, 7, 8). No unique technology has been identified as being required for burning waste oil as a fuel. Pre-treatment of waste oil for removal of solids and water is recommended for alleviation of technical and operational problems associated with burning waste oil. A pre-treatment system has been included in the project. A rotary cup burner and a fire-tube boiler have been selected as most suited to waste oil firing.

The supply of waste oil at Hay River is more than sufficient to meet the fuel requirements of the proposed facility. Approximately 400,000 litres/year waste oil have been identified at Hay River. Fuel requirements are 275,000 litres/year. Presently, 350,000 litres are assessed as being freely available to the Town.

The environmental viability of the project appears to be good, as emissions of hazardous contaminants are not likely to exceed allowable levels set by various agencies. An environmental benefit may be recognized if this facility is an improvement over current disposal methods. Almost all waste oil identified at Hay River is currently burned or used for road oiling. In both instances, hazardous contaminants are discharged directly to the environment. Many organic contaminants are destroyed during the combustion process and are not released to the environment. A portion of the contaminant metals in the waste oil is released to the environment during burning, the balance is concentrated in the ash residue.

The economic viability is reasonable. In Section 9.2 a capital cost of \$312,100 to \$327,100 was estimated. In Section 9.3, operating and maintenance costs were estimated to be \$23,000 annually. This cost is incremental to O & M costs for the existing facility.

The fuel requirements for the domestic water heating system have been estimated to be 275,000 litres annually. Cost of fuel for the 1983-84 heating season was 28.9 cents/litre, resulting in a total cost of \$79,500. This was a very low fuel oil price and resulted from competition among the fuel oil suppliers at Hay River. The cost of fuel for the 1984-85 heating season has been estimated to be 35 cents/litre. Projected fuel cost for the 1983-84 season is \$96,250.00

Fuel costs for a range of fuel prices have been calculated in Table 10.1-1. The anticipated savings in O & M costs, associated with the implementation of a waste oil heating season, is also given in Table 10.1-1.

In Table 10.1-2 Simple Payback Periods for the capital investment are calculated. The anticipated savings for a range of virgin fuel prices (Table 10.1-1) are considered.

For fuel prices ranging from 35 to 40 cents/litre in the next few years, a simple economic payback period of 3 - 3.75 years is calculated.

On a discounted cash flow basis, a capital investment of \$262,100 that results in annual savings of \$73,250 per year for 10 years represents an investment that earns a compound rate of return equal to 25%; a 20 year project lifetime, 28%.

TABLE 10.1-1 ANNUAL SAVINGS IN OPERATING & MAINTENANCE COSTS
ASSOCIATED WITH WASTE OIL HEATING

Virgin Fuel Price 275,000 litres ¢/litre	\$/year	Incremental O & M Cost for Waste Oil System \$/year	Annual Savings in O & M Cost \$/year
30	82,500	23,000	59,500
35	96,250	23,000	73,250
40	110,000	23,000	87,000
45	123,750	23,000	100,750
50	137,500	23,000	114,500

TABLE 10.1-2 STRAIGHT PAYBACK PERIOD FOR INSTALLATION OF
WASTE OIL HEATING SYSTEM

		Simple Payback Period in Years Capital Cost / Annual Savings			
Virgin Fuel Price ¢/litre	Annual Savings \$/year	- - - - - Capital Cost - - - - -			
		\$312,100 ^a	\$327,100 ^a	\$262,100 ^b	\$277,100 ^b
30	59,500	5.25	5.50	4.41	4.59
35	73,250	4.26	4.47	3.58	3.73
40	87,000	3.59	3.76	3.01	3.14
45	100,750	3.10	3.25	2.60	2.71
50	114,500	2.73	2.86	2.29	2.38

a: Capital Cost includes \$50,000 for monitoring program for emissions and residues

b: Capital Cost does not include \$50,000 for monitoring program for emissions and residues.

10.2 IMPACT ON VIABILITY DUE TO CHANGES IN ASSUMED OPERATION

10.2.1 General

The economic viability of the project discussed in the previous section is a function of the capital cost of the facility, and the incremental operating and maintenance cost of the proposed facility in relation to the existing facility.

The anticipated savings can increase with either a reduction in operating & maintenance requirements for the waste oil heating system or with an increase in the price of virgin fuel (existing facility).

In the following sections, the sensitivity to project viability due to changes in assumed capital and operating and maintenance costs for the proposed facility are discussed.

10.2.2 Capital Costs

A capital cost of \$312,100 to \$327,100 has been estimated for the waste oil heating system. The cost of a monitoring program for hazardous emissions and residues (\$50,000) is included in the estimate. If Environment Canada or some other agency assumed the financial responsibility for any monitoring program, accordingly, the baseline capital cost to the Town is \$262,000.

All tankage in the project has been specified as new. The use of used tanks has not been eliminated as a possibility. The availability and suitability of used tanks would determine their use. Tankage costs may be reduced through the use of used tanks. The most likely applications of used tankage are the residue storage tanks and possibly the 'front end' collection tanks in the pre-treatment system.

The bulk fuel storage tanks have been specified as 4 x 75,000 l tanks, at a cost of \$48,500. An alternative is 2 x 150,000 l tanks at a cost of \$43,500, a savings of \$5,000, or 10%. Operating and maintenance costs would increase with larger storage tanks due to increased power requirements for heating and mixing of fuel in storage.

The circulating pump and the in line heater in the storage system can be used in the pre-treatment system. Anticipated savings are \$4,700 total.

Capital cost for equipment is not extremely variable. Minor changes in design, use of used equipment, etc. could possibly cut the capital cost by as much as \$20,000 (including savings noted above.)

A major portion of the capital cost of the project is related to other services. The budgeted \$128,000 includes piping, contracting (mechanical/structural, electrical), detail engineering and project management, etc. and the monitoring program. Excluding the monitoring program, the services portion of the project is \$78,000. An additional \$6,000 has been estimated for engineering and preparation of the tank storage site. For sensitivity analysis the total value, \$84,000, is allowed to fluctuate up or down by 10%.

Accordingly, the following three levels of capital cost are used in the sensitivity calculations in Section 10.2-4 to illustrate the effect on project economic viability due to reasonable changes in the baseline capital costs.

\$262,100 - lower cost as determined in Section 9.2 less the cost of the monitoring program (baseline).

\$233,700 - as above, less \$20,000 for reduced equipment cost, less \$8,400 for reduced cost of services (piping, contracting, etc.)

\$285,500 - higher cost as determined in Section 9.2, less cost of the monitoring program, plus \$8,400 for increased cost of services (piping, contracting, etc.)

10.2.3 Operating and Maintenance Costs

The sensitivity to project viability of some of the operating and maintenance costs was discussed in Section 9.3 (i.e. labour requirements, collection costs, effect of water contamination in the waste oil collected, etc.). The baseline operating and maintenance cost is \$23,000 annually.

Three levels of operating and maintenance costs are used in the sensitivity calculations (Section 10.2.4). In the following discussion, the basis for selection of these costs is examined more closely.

Labour Requirements

The labour requirements of the pre-treatment and boiler systems were deliberately over assessed in Section 9.3.

Pre-treatment system (Table 9.3-2)

$$40 \text{ days/year} \times 8 \text{ hrs/day} \times \$25/\text{hr} = \$8,000/\text{year}$$

Cleaning of rotary cup burner (Table 9.3-4)

$$150 \text{ days/yr} \times 1 \text{ hr/day} \times \$25/\text{hr} = \$3,750/\text{year}$$

These two items total \$11,750, and represent 50% of the operating and maintenance costs calculated in Section 9.3.

The actual requirement for the pre-treatment system will be determined by the capacity of the centrifuge selected. The volume of waste oil to be centrifuged will not be the collected volume. Gravity settling of the collected oil and decanting the water layer will reduce the processing volume. Twenty-five days operating time (\$5,000) is more likely the actual requirement. Operating and maintenance costs are reduced by \$3,000.

The frequency of cleaning the burner will be determined through usage. The burner supplier suggests 1/2 hour per week as the maintenance requirement. In the sensitivity analysis 1.5 hours per week (\$825/yr. total cost) is considered (versus 7 hrs/week in the baseline, costed at \$3,750/year). Operating and maintenance costs are reduced by \$2,925.

The operating and maintenance cost previously determined is \$23,000. With the reduced labour requirements outlined here, the operating and maintenance cost is \$17,075, a 25% reduction.

Water Contamination of Collected Waste Oil

The waste management practices of producers of waste oil will have the most direct effect in reducing operating and maintenance costs of the collection and pre-treatment systems. In Section 9.3, 20% water contamination was assumed to be average for collected waste oil.

In Table 10.2-1, operating and maintenance costs affected by water contamination are determined for a range of water contents. A base line of \$23,000 per year (20% water content) is used to determine the net effects on the operating and maintenance cost.

At 10% water, operating and maintenance costs are reduced to \$20,755 or 90% of the \$23,000 baseline. At 40% water, operating and maintenance costs are increased to \$29,760, almost 30% above

the baseline. Note from the Table 10.2-1 that wastewater disposal cost is the largest factor in the increased cost.

TABLE 10.2-1 EFFECT OF WATER CONTAMINATION ON OPERATING & MAINTENANCE COST FOR WASTE OIL HEATING SYSTEM

	Water Contamination in Collected Waste Oil			
	10%	20%	30%	40%
Volume				
Fuel (000's litres)	275	275	275	275
Water (000's litres)	31	69	119	183
Total Collected Volume (000's litres)	306	344	393	458
Collection Cost (\$100/bbl) \$/year	1915	2150	2455	2865
Demulsifier (0.1% @ \$3/L.) \$/year	920	1030	1180	1375
Wastewater Residue Disposal (@ \$8/bbl) \$/year	1550	3450	5900	9150
Total	4385	6630 ^a	9535	13390
Change from baseline	-2245	0	2905	6760
Net Cost \$/year	20755	23000	25905	29760
% of baseline	90	100	113	129

^a baseline cost, 23,000/year, operating & maintenance cost based on 20% water in collected waste oil.

1 barrel = 160 litres approximately. Barrel measures are used in cost estimating since the haul vehicles volumes and their owner's prices for services were quoted in 'barrels'.

Residue Disposal Costs

In the determination of operating and maintenance costs, allowances have been made for residue disposal: \$8/bbl ($\$50/\text{m}^3$) for wastewater, \$11/bbl for sludge residue. A lump sum of \$250 has been allowed for disposal of boiler ash.

Wastewater disposal costs have the most significant effect on the operating and maintenance cost. In Table 10.2-2, disposal costs have been determined for a range of disposal prices and water content. The baseline prices were taken from Table 10.2-1, (net cost \$/year).

At low water content, the disposal cost does not affect operating and maintenance costs seriously. At 10% water the variance between \$4/bbl ($\$25/\text{m}^3$) and \$12/bbl ($\$75/\text{m}^3$) disposal costs is \$1550, or 7.5% of the baseline price of \$20,755. At no charge for disposal (i.e. dump at site), the operating and maintenance costs are reduced to \$19,205, 93% of the baseline. At higher levels of water contamination, disposal cost becomes a more significant portion of the total operating and maintenance costs. At 30% water, the variance between \$4/bbl and \$12/bbl is \$5990, almost 25% of the baseline cost of \$25,905. At no charge for disposal, operating and maintenance costs are reduced to \$19,915, 77% of the baseline.

It is obvious from the table that wastewater disposal cost can become a significant portion of the operating & maintenance costs. Waste management by producers of waste oil will minimize the effects of disposal cost; low water content will reduce the disposal cost and lessen the effect. Selection of wastewater disposal method will be based on the volume for disposal. As the water content of collected waste oil increases, it is more critical that a low cost method is selected.

In Section 9.3, the volume of sludge residue for disposal was assumed to be 1% of the collected volume. An allowance was made for disposal of 20 bbl (3,200 l) at \$11/bbl (including transportation). The sludge disposal cost was \$220, or approximately 1% of the total operating and maintenance cost of \$23,000. If both the volume of sludge and cost of disposal were to double, sludge disposal cost would be \$880. The operating and maintenance cost would increase by \$660, or 3%. The operating and maintenance costs are not really sensitive to sludge disposal cost.

An allowance of \$250 has been made for boiler ash disposal. This is a small component of the operating and maintenance costs. As with the sludge, operating and maintenance costs are not really sensitive to ash disposal cost.

Collection Costs

In Section 9.3.2, a collection cost of \$65/50 bbl (\$81/m³) was used to determine the annual collection cost.

At 20% water contamination in the collected waste oil, the collection cost to assemble a net 275,000 litres of fuel was calculated to be \$2,800/year, 12% of the annual operating and maintenance cost of \$23,000/year.

In Table 10.2-3, collection costs have been determined for a range of water contents in the waste oil. Two collection vehicles are specified, 50 bbl and 100 bbl capacity. The collection cost includes multiple source pick ups, delivery to the receiving tank at the pumphouse and return to town. A larger collection vehicle will result in lower collection costs.

TABLE 10.2-2 EFFECT OF WASTE WATER RESIDUE DISPOSAL COST IN
OPERATING & MAINTENANCE COST FOR WASTE OIL
HEATING SYSTEM

	Water Content of Collected Waste Oil		
	10%	20%	30%
Waste water residue volume (000's litres)	31	69	118
Total disposal charge ^a = \$8/bbl (\$50/m ³)	1550	3450	5990
Baseline Total O&M Cost (Net cost \$/yr from Table 10.2-1)	20755	23000	25905
Total disposal charge = \$12/bbl (\$75/m ³)	2325	5175	8940
Net change from baseline	775	1725	2950
Adjusted Total O&M Cost	21530	24725	28855
% of baseline	104	108	111
Total disposal charge = \$4/bbl (\$25/m ³)	775	1725	2950
Net change from baseline	-775	-1725	-2950
Adjusted Total O&M Cost	19980	21225	22865
% of baseline	96	92	88
Total disposal charge = 0	0	0	0
Net change from baseline	-1550	-3450	-5990
Adjusted Total O&M Cost	19205	19550	19915
% of baseline	93	85	77

^a includes disposal fee and transportation charges

TABLE 10.2-3 COLLECTION COSTS FOR RANGE OF WATER CONTENT
AND COLLECTION FEES

	Water Content of Collected Waste		
	10%	20%	30%
Volume Collected (litres)	306,000	344,000	393,000
	\$/yr	\$/yr	\$/yr
50 bbl (8300 litres)			
Collection Vehicle			
\$40/collected load	1,530	1,720	1,965
\$50	1,920	2,150	2,455
\$60	2,295	2,580	2,950
\$65	2,485	2,759	3,195
100 bbl (16000 litres)			
Collection Vehicle			
\$50/collected load	955	1,075	1,230
\$65	1,245	1,400	1,595
\$80	1,530	1,720	1,965
\$100	1,915	2,150	2,455

Operating & Maintenance Cost for Sensitivity Analysis

Three levels of operating and maintenance cost will be used in the sensitivity analysis.

\$23,000/year - as determined in Section 9.3.

\$11,775/year - based on 10% water in collected waste oil, pre-treatment system operation 20 days/year, burner maintenance 1.5 hours/week, collection cost \$80/100 bbl, no charge for wastewater residue disposal, \$11/bbl for sludge residue disposal, and power usage and cost remain the same.

\$17,400/year - an intermediate value to the two values above.

The operating and maintenance costs can vary far more than the capital costs. The values above represent 50, 75 and 100% of the operating and maintenance costs determined in Section 9.3.

10.2.4 Sensitivity Analysis

In Table 10.2-4 and Table 10.2-5, simple economic payback periods have been calculated.

Three levels of capital cost and three levels of operating and maintenance cost have been selected for sensitivity analysis as noted earlier:

Capital Cost: \$262,100 (baseline); \$233,700; \$285,500
O & M Cost: \$ 23,000 (baseline); \$ 11,775; \$ 17,400

Baseline values were used in Section 10.1 to assess the viability of the waste oil project.

Two levels of virgin fuel prices are used, 35 and 40 cents/litre. The value of virgin fuel over the next few years is likely to be within this range. For the 1984-85 heating season, a virgin oil price of 35 cents/litre has been assumed.

TABLE 10.2-4 SENSITIVITY ANALYSIS - SIMPLE PAYBACK PERIODS
FOR VARYING CAPITAL AND O & M COSTS
Virgin Oil Price: 35 cents/litre

Incremental O&M Costs	Virgin Oil Price	Annual Savings	CAPITAL COSTS		
			\$262,100	\$233,700	\$285,500
			Payback Period (Years)		
23,000	96,250	73,250	3.6*	3.2	3.9
11,775	96,250	84,475	3.1	2.8	3.4
17,400	96,250	78,850	3.3	3.0	3.6

TABLE 10.2-5 SENSITIVITY ANALYSIS - SIMPLE PAYBACK PERIODS
FOR VARYING CAPITAL AND O & M COSTS
Virgin Oil Price: 40 cents/litre

Incremental O&M Costs	Virgin Oil Price	Annual Savings	CAPITAL COSTS		
			\$262,100	\$233,700	\$285,500
			Payback Period (Years)		
23,000	110,000	87,000	3.0*	2.7	3.3
11,775	110,000	98,225	2.7	2.4	2.9
17,400	110,000	92,600	2.8	2.5	3.1

* payback period for the baseline estimate (excluding monitoring program costs).

10.3 PAYMENT FOR USED OIL

Used lubricating oils have a market value of 13.2 cents/litre (60 cents/gallon), FOB Turbo Refinery, Edmonton. Transportation charges, Hay River to Edmonton, are 3.4 cents/litre on a back haul rate. Value of used lube oils at Hay River is therefore 9.8 cents/litre. In this section, the consequences of payment for used oil are examined.

In Tables 10.3-1 and 10.3-2, the same payment is assumed to be made for all waste oil collected, independent of source or type of waste oil. The simple payback periods are determined using the two baseline levels of capital investment (not including the monitoring program) and the baseline operating and maintenance cost (\$23,000). Two virgin fuel price levels are used to determine the annual savings.

TABLE 10.3-1 SENSITIVITY ANALYSIS - SIMPLE PAYBACK PERIODS
FOR VARYING CAPITAL AND O & M COSTS
Virgin Oil Price: 35 cents/litre

Payment for Waste Oil (275,000 L) ¢/L. \$/yr.		Virgin Fuel Cost \$/year	Incremental O&M Cost* \$/year	(3) - (4) - (5) Annual Savings \$/year	Capital Cost 262,100 277,100	
					Payback Period (Yrs)	
0	0	96,250	23,000	73,250	3.6	3.8
2	5,500	96,250	23,000	67,750	3.9	4.1
5	13,750	96,250	23,000	59,500	4.4	4.7
9.8	26,950	96,250	23,000	46,300	5.7	6.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)

* from table 9.3-6

TABLE 10.3-2 SENSITIVITY ANALYSIS - SIMPLE PAYBACK PERIODS
FOR VARYING CAPITAL AND O & M COSTS
Virgin Oil Price: 40 cents/litre

Payment for Waste Oil (275,000 L) ¢/L. \$/yr.		Virgin Fuel Cost \$/year	Incremental O&M Cost* \$/year	(3)-(4)-(5) Annual Savings \$/year	Capital Cost 262,100 277,100	
					Payback Period (Yrs)	
0	0	110,000	23,000	87,000	3.0	3.2
2	5,500	110,000	23,000	81,500	3.2	3.4
5	13,750	110,000	23,000	73,250	3.6	3.8
9.8	26,950	110,000	23,000	60,050	4.4	4.6
(1)	(2)	(3)	(4)	(5)	(6)	(7)

* from table 9.3-6

10.4 IMPACT ON VIABILITY DUE TO INCREASE IN MUNICIPAL WATER CONSUMPTION

An increase in heating demand can be handled by both the existing boiler and the proposed waste oil fired boiler. The current operating day is estimated to be 12-16 hours. For a 25% increase in demand, the fuel requirements would increase from 275,000 litres to 344,000 litres. The fuel cost for use of virgin fuel in the existing facility with a 25% increase in demand is given in Table 10.1-3, for a range of virgin fuel prices.

If the waste oil fired heating system were to be used to meet the increased demand, additional storage is required (i.e. 1 x 75,000 litre tank, heated and insulated). The capital cost of the tank, set in place at the site is \$12,100. (Assuming no additional costs for tank site preparation). This is the only necessary capital expenditure associated with the increase in fuel demand.

Some of the operating and maintenance costs associated with the waste oil heating system would increase; specifically in the collection and pre-treatment system. Power costs in the storage system would also increase. These are given in Table 10.1-4. As shown in the table, for the same heating demand increase of 25%, the increased operating and maintenance requirements for the waste oil heating system are only \$2,615 or 11% of the increase in virgin fuel price.

Therefore, if the municipal water heating demand increased by 25%/year, the investment in a waste oil fired heating system is even more lucrative. If the prevailing virgin fuel oil costs were 35¢/l the annual cost savings provided by waste oil are: \$73,250 (Table 10.1-2) + \$24,150 (Table 10.1-3) - 2,615 (Table 10.1-4) = \$94,785/annum, as opposed to the \$73,250 for the lower fuel demand case (Table 10.1-2). The extra annual savings, (\$94,785-\$73,250=) \$21,535 can be used to recover the \$12,100 added capital cost in tankage in less than seven months.

TABLE 10.1-3: VIRGIN OIL FUEL PRICE

Cents/litre	344,000 litres \$/year	275,000 litres \$/year	Increase in Cost (\$/year)
35	120,400	96,250	24,150
40	137,600	110,000	27,600
45	154,800	123,750	31,050
50	172,000	137,500	34,500

TABLE 10.1-4: INCREASED OPERATING & MAINTENANCE COSTS FOR
A WASTE OIL FIRED HEATING SYSTEM WITH A
25% INCREASE IN FUEL DEMAND (ASSUMED 10%
WATER CONTAMINATION)

	Base Case	25% In- creased Demand	Difference
Collection cost (100 bbl collection vehicle, 100 bbl/hr)	\$1,905	\$2,390	\$ 485
Operation of pre-treatment system (allow 5 extra days, \$200/day)			1,000
Demulsifier (0.1% addition, \$3/litre)	915	1,145	230
Waste water residue disposal (\$8/bbl)	1,500	1,900	400
Sludge residue disposal (\$11/bbl)	210	260	50
Power costs (assume 25% increase in total power requirement)	1,800	2,250	450
TOTAL INCREASE IN OPERATING & MAINTENANCE COSTS			\$2,615/ year

10.5 BENEFITS

There are two benefits that accrue from the installation of a waste oil fired heating system at Hay River. The first benefit is the annual savings to the Town. The second benefit is the development of a disposal method for waste oil with minimal environmental impact.

Cost savings is the primary justification for this and other installations. The Town of Hay River currently spends almost \$100,000/year for fuel to heat the domestic water supply. The incremental operating and maintenance costs associated with the waste oil system are \$23,000/year or less. The annual savings are approximately \$73,000 for a current fuel price of 35 cents/litre. At higher fuel prices, the savings increase directly.

The Town has a population base of 3,200. Cost of fuel for the existing facility is estimated to be \$96,250/year (275,000 litres @ 35 cents/litre). This represents a heating cost of \$30.08 per capita for heating of water only (pumping water to the Town is estimated to cost an additional \$100,000 annually). The operating and maintenance cost for the proposed waste oil facility has been estimated at \$23,000/year, reducing the heating cost to \$7.18 per capita, less than 25% of the current heating cost.

The second benefit is less direct and more difficult to assess than the first. Disposal of waste oil is a major problem in some areas of the north. Transportation charges are too high to consider returning the waste to refineries where it can be reclaimed. Other disposal methods must be used. Burning and road oiling are the most common methods identified.

Combustion of the waste oil, with heat recovery is a good alternate to the disposal methods now in place. The lubricating quality of the oil is still lost - as it is with burning or road

oiling. However, the heating quality of the oil is utilized. Neither burning or road oiling utilize the heat value of waste oil. The environmental impact of controlled combustion with heat recovery is equal to or less than the impact from burning. Through controlled combustion, organic contaminants in the waste oil are almost completely destroyed (Destruction Removal Efficiency > 99%). Metal contaminants either subside to a residue or are emitted as particulate matter.

Use of waste oil as a dust suppressant utilizes neither the heating quality or the lubricating quality of the oil. All contaminants are released directly to the environment. High ground level concentrations may result. Run-off from roads may cause contamination of surface and ground waters. Road oiling is assessed as posing a greater threat to the environment than either burning or combustion with heat recovery.

The waste oil fired heating system described in this report can be considered for a disposal method at several northern communities (Yellowknife, Pine Point, Beaufort area).

11.0 ALTERNATE DISPOSAL FOR USED OIL AND CONTAMINATED FUEL

11.1 GENERAL

There are several disposal methods for used oils and contaminated fuels which have been identified at Hay River. Used lubricating oils are used for dust suppression on roads and yards. Bassett Trucking has collected used oil and sold the oil to the Turbo Refinery at Edmonton. Some of the companies surveyed claim they disposed of used oil at the town dump where it is incinerated. In fact, the town has used some of this oil as dust suppressant. Contaminated fuels are used for firefighting practice, burning the lagoon or as fuel for space heating.

11.2 CONTAMINATED FUEL DISPOSAL METHODS

Contaminated fuels are generated by the bulk oil companies and the marine transport companies. If the fuel can be reclaimed for use as a fuel, the owner of the fuel will do so. Otherwise it is designated slops and discarded.

Slops and retain from washdowns, drum ends, etc., are also discarded, and are included as contaminated fuels.

There were four contaminated fuel disposal methods identified at Hay River.

- 1) The Ministry of Transport (MOT) collects contaminated fuels for fire fighting training sessions at the airport at Hay River and other locations. MOT also provides fire fighting training to the Town of Hay River and to private companies (eg. NTCL).
- 2) The Town of Hay River uses contaminated fuels to burn off other waste in sewage lagoons.

- 3) Kingland Ford collected contaminated fuels (1984) for use in a space heater to be installed in the garage.
- 4) The Esso Bulk Plant operator indicated the retain is too messy for re-refining and is shipped to Edmonton for disposal.

The bulk of the contaminated fuels identified are generated by the marine transport companies (NTCL and ATL). Both companies indicated that contaminated fuels were given to MOT and the Town.

The first two disposal methods identified can be considered recycling of the contaminated fuels. If the contaminated fuels were not available, fuel would have to be purchased as the fire drills and lagoon burning are both necessities. Similarly, Kingland Ford would have to purchase other fuel to heat the garage.

11.3 USED OIL DISPOSAL BY ROAD OILING

The most common method of disposal for used lubricating oil in Hay River and in the north generally, is road oiling. Dust suppression on northern roads is a necessity, and used lubricating oil is the most available and least expensive agent.

The effectiveness and hazards of used oil as a road dust suppressant are well documented (ref. 10). Proper application of the oil is essential, for example:

- 1) Upgrade the surface course. Rework the old surface course or add new lift prior to application of suppressant or application of new lift aggregate; old surface should still be repaired through ditching and grading.
- 2) Final surface material should be of proper size and content. Final surface course should be properly shaped.
- 3) Final surface grade should be tight bladed.
- 4) During application, suppressant should be at or slightly below optimum moisture content to ensure penetration without pooling or run-off.
- 5) Following application of the suppressant, compact the final road surface to ensure good penetration and particle cohesion.
- 6) Application rates of used oil are 1.1 - 1.7 litres/m², with 2 applications/year.
- 7) Water content of waste oil for dust suppressant is 4.4% on average.

If not properly applied, the effectiveness of used oil as a dust suppressant is very low. A study (ref. 10) has shown that less than 1% of the applied oil remains on the road after the first rainfall.

Used oil as a dust suppressant presents a serious environmental threat due to contaminant heavy metals (especially lead), PCB's, PNH's. Runoff from roads can contaminate surface and ground waters.

Several producers of used lube oil indicated they used the waste for dust suppression in their yard.

11.4 RE-REFINING OF USED LUBRICATING OILS

Used lubricating oil may be reclaimed (solids and water removal only) or re-refined (removal of solids, water, contaminants acquired during use and original additives). Re-refining used oil is a recycling process in that the original lubricating quality of the oil is maintained.

Several re-refining processes are available. The more common processes are discussed here (References 8, 9, 12). The typical products from re-refining processes are distillate fuels, lubricating and hydraulic oils, cutting oils and machine oils. Often segregation of wastes is critical as all types of contamination (solvents, fuels) cannot be handled in the refining process.

Acid Clay

The acid clay process is the oldest of the re-refining technologies. The Turbo Re-refinery at Edmonton, utilizes this process. There are four stages in the process:

- 1) removal of water and light ends in a steam stripping tower;
- 2) acidification and heating (40°C) for
 - extraction of impurities
 - formation of tar sludge which settles out
- 3) fractionation (290°C - 343°C) of remaining waste oil into streams.

- 4) filtration of distilled products through a clay bed for removal of contaminants and colour inducing bodies.

There are various problems associated with the acid-clay process: the acidification step can cause sulphonation of the non-saturated oil fraction; oils with detergents are not readily treated with this process; chemical requirements (acid and clay) are higher for advanced multigrade oil formulation. The acid, tar and spent clay residuals are highly corrosive; and the sludges are high in heavy metals. The acid clay process produces high volumes of waste (0.4 kg/litre product). The acid containing sludges must be neutralized and require "safe" disposal to the environment. This may be a problem in the north.

Phillips Re-refined Oil Process (PROP)

This process offers several advantages over the acid-clay process. The recovery is higher (90%) and the residues are more easily disposed (by-product filter cake to landfill, aqueous phase to municipal sewer system).

PROP process steps are:

- 1) contact of waste oil with diammonium phosphate (DAP) for precipitation of metallic phosphate compounds.
- 2) apply heat for removal of water and light ends (150°C)
- 3) filtration for removal of particulate and precipitated phosphates
- 4) clay filtration for removal of trace inorganic and colour bodies
- 5) hydrotreating over a nickel molybdate catalyst for removal of sulphur, nitrogen, oxygen and chlorine compounds
- 6) flashing for separation of light ends
- 7) stripping for removal of residual fuel oil

A by-product of the process is heavy gasoline (diesel-fuel type)

which can be sold.

KTI Process

The KTI Process steps are:

- 1) dehydration
- 2) vacuum distillation (2 by-products; light gas oil and heavy residue. The residue can be used for road surfacing or as a heavy fuel power plant).
- 3) hydrofinishing - the products are flashed for recovery of excess hydrogen and either stripped with steam for removal of light ends or fractionated into desired lubricating oil cuts.

The process yields 82% lube oil and 8% heavy residue bottoms. The balance (10%) represents lighter fractions.

Recyclon Process

The Recyclon Process steps are:

- 1) dehydration and removal of light ends in stripping column
- 2) sodium dispersion is contacted with the waste oil
- impurities in oil transform to compounds (salts or polymers) which cannot be distilled and are separated from the oil in subsequent processing.
- 3) a series of thin film evaporators is used to obtain the desired lubricating oil cuts.

The process yields 70% re-refined lubricating oil, the balance is fuel. Water from first processing stage is acidic. After neutralization it can be sewered.

Environmental Factors of Refining

Waste streams from re-refining facilities often concentrate hazardous contaminants from the waste oil. A list of wastes and the disposal practices is given below.

Waste Stream	Source (Process)	Disposal
aqueous wastes	dehydration unit receiving tank bottoms	biological treatment
lead sludge, other metals	acid tar sludge (acid clay) spent DAP solution (PROP)	incineration, secure landfill
Non-condensed vapour air emissions	distillation columns	control device for HCL and SO ₂ emissions
Still bottoms	distillation columns	incineration, secure landfill
Spent catalyst	hydrotreating (PROP and KTI)	secure landfill

Applicability of Rerefining in the NWT

The assessment of suitability of a rerefining industry in the north must consider the volumes and type of used oils available and the potential markets for rerefined lubricating oils.

The potential markets do exist. There are several mines, NCPC operations, marine and truck transport companies which are all large users of lubricating oils. The quality of the rerefined lube oils would determine the usage by any or all of the sectors. It is assumed that the quality of the product is acceptable and that all of the product will be used.

The capital costs of rerefining are significant, and large capacity plants are required for economic viability. A recent report (Ref. 3) gives the following costs for skid-mounted PROP units.

Capacity		Capital Cost (excluding land, feed product storage & service)	Approximate Operating & Maintenance
m ³ /yr	bbl/day		
7,600	130	\$2,300,000 ^a	\$ 600,000/yr ^a
18,900	325	3,900,000	1,200,600
37,900	650	5,400,000	2,200,000

^a 1980 dollars

The volumes of waste oil generated at Hay River are insufficient (400,000 litres/year = 400 m³/year = 6.8 bbl/day) to support the newer technologies. Acid-clay is the only process which is suited to small volumes. However, capital costs still make the installation of a rerefinery at Hay River not viable. Note that rerefining cannot be used for disposal of solvents and contaminated fuels.

11.5 **ALTERNATE BURNING USES**

Space Heaters

Kingland Ford at Hay River has installed a waste oil burner in their garage. The burner is capable of burning waste fuels and oils and is reportedly a successful installation.

There are two types of space heaters available (reference 18, 21, 25). The vaporizing type of unit vaporizes the fuel prior to burning. The inorganics are not vaporized and remain in the furnace rather than being emitted to the environment in the flue gas. The metal contaminants prevalent in automotive used oil (especially lead) concentrate in the ash residue of the vaporizing burner. Disposal of the ash should be to secure landfill.

The second type of waste oil burner on the market is an atomizing burner. The fuel is atomized prior to burning, and nearly all the inorganics are emitted with the flue gas. A major concern in the use of this design of space heaters is that there is no pollution control equipment on the furnace and the stack height (usually building height) is very low. There is no dispersion of pollutants, and ground level concentrations can be very high.

The number of installations of space heaters at Hay River will likely increase in the next few years. They are usually installed on the premises of a producer of waste oils (eg. service station, heavy duty equipment repair shop, etc.)

Cement Kilns

Use of waste oil as a fuel in cement kilns is an accepted waste oil disposal method (reference 11). High temperature and long residence times aid in destruction of organics. Contaminants in the waste oil which are not destroyed through combustion are

contained in cement clinker. No environmental threat is assumed. There are no cement kilns in the north.

Asphalt Plants

Waste oil has been used as a fuel in mobile asphalt plants. As contaminants are discharged directly to the environment, this practice is discouraged.

11.6 COLLECTION OF USED OIL FOR REREFINING

Collection of used lubricating oil in the community would eliminate the following practices:

- 1) dumping at source; likely contamination of surface and ground waters;
- 2) dumping to sewer; oil can kill the biological action in a sewage lagoon;
- 3) oiling of roads and private yards; in many cases this practice is akin to dumping at source. The oil must be properly applied for there to be any benefit as a dust suppressant.

If a decision is made not to use waste oil as a fuel at the intake pumphouse, a used oil collection system can still be implemented at Hay River. In section 10.3, used lube oil was noted to have a value of 9.8 cents/litre FOB Hay River. There has been 250,000 litres of used oil identified at Hay River, with a potential value of \$24,500. A local service group could implement the collection system, and the funds generated used for community projects.

12.0 RECOMMENDATIONS AND SUGGESTIONS

12.1 CONCLUSIONS

The salient conclusions from this assignment are summarized in the following paragraphs. Substantiation for these conclusions can be found in relevant sections in the report.

Chapter 1.0

Not Applicable

Chapter 2.0 - Waste Oil at Hay River

- a) A significant volume of waste oil is generated at Hay River, 400,000 litres annually. The waste oil is comprised of 150,000 litres contaminated fuel and 250,000 litres used lubricating oils and solvents.
- b) Disposal of waste oil is a problem for only some of the producers. Disposal methods and uses for waste oil were identified as road and yard oiling, burning and return to Edmonton for re-refining.
- c) Most producers of waste oil would make the waste freely available to the Town. Some producers would retain the waste for their own purposes. 350,000 litres of waste oil were assessed as being available to the Town.
- d) A significant volume, >475,000 litres/year, waste oil is generated at Pine Point. Cominco Mines is the major producer of waste oil (455,000 litres/year), and currently use 100% of waste oil generated for dust suppression.

Chapter 3.0 - Waste Oil as a Fuel

- a) Waste oil has is used as a fuel for 50-60,000 installations in the United States. Often it is blended with virgin oils (No. 2 or No. 6 Residual) or coal.
- b) Solids and water contamination of waste oil fuel create serious technical and operational problems. Pre-treatment of the waste oil for removal of solids and water will alleviate the problems.
- c) Contaminants which are soluble in waste oil are not removed during the pre-treatment process. Most of the metal contaminants of concern are soluble in oil, and contribute to emissions and fouling of the heat transfer surfaces.
- d) Sampling and analysis of waste oil at Hay River showed good fuel properties and generally low level contamination. A comparison to waste oils in the literature indicated that waste oil collected at Hay River is at the very low end of contaminant levels generally reported.

Chapter 4.0 - Technology of Burning Waste Oil

- a) A fire tube boiler and rotary cup burner are most suited to waste oil firing.

Chapter 5.0 - Emissions

- a) The emissions of most concern from any facility burning waste oil are metals (arsenic, barium, cadmium, chromium, lead, zinc), chlorinated organics and halide acids.
- b) Air quality impact modelling of waste oil burning has shown that emissions of lead, barium, and hydrogen chloride could have a potentially significant impact on the environment

(eg. air quality).

- c) Application of the same model to the fuel assumed for Hay River showed the relatively largest impact on the environment from lead and barium emissions. Maximum 30 day concentrations for lead determined in the model, were less than 5% of the expected standard for lead emissions from the proposed facility.
- d) The expected standard for lead emissions from the waste oil fired heating system are the Secondary Lead Smelter Regulations (Clean Air Act). Ground level concentration standards are expected to be equal to the Province of Ontario Secondary Lead Smelter Regulations.

Chapter 6.0 - Hazardous Waste

- a) Waste oil may be classified as a hazardous waste in upcoming federal legislation. Collection, transport, storage and disposal of hazardous wastes will be regulated in the legislation.
- b) Exemptions may be made for recycling practices. Burning waste oil for heat recovery may be considered recycling.
- c) Residues from the pre-treatment process may be defined as hazardous waste in up-coming federal legislation. At that time, disposal of residues must comply with the regulations.

Chapter 7.0 - Concept for Waste Oil Fired Heating System

- a) Fuel requirement for heating system is 275,000 litres/year.

Chapter 8.0 - Collection and Pre-treatment of Waste Oil

Not Applicable

Chapter 9.0 - Capital Costs and Operating and Maintenance Costs

- a) Capital cost of the project is estimated at \$312,100 - \$327,100, including \$50,000 for an environmental monitoring program.
- b) The incremental operating and maintenance costs associated with the waste oil system are estimated to be \$23,000/year.

Chapter 10.0 - Viability and Benefits

- a) The annual savings are estimated to be \$73,250 and the simple economic payback period on a capital investment of \$262,100 to \$277,100 is 3.6 to 3.8 years, based on a current virgin fuel oil price of 35 cents/litre.
- b) On a discounted cash flow basis, the capital investment of \$262,100, shows an equivalent rate of return of 25% over 10 years.
- c) A technically and economically feasible waste oil fired heating system can be implemented at the Hay River intake pumphouse.

Chapter 11.0 - Alternate Disposal Methods

- a) The concept of a re-refining industry in the NWT is not economically viable.
- b) Road oiling for dust suppression is common practice in the north.
- c) Returning collected used oil to Edmonton is economically viable.

- d) The only recognized disposal method for contaminated fuels is combustion.

12.2 RECOMMENDATIONS AND SUGGESTIONS

The installation of a second heating system, to be fired by waste oil, at the intake pumphouse is recognized as a good investment. The Town Manager has indicated that the Town would be interested in the facility only if 1) it was economically viable, and 2) emissions did not pose a serious environmental risk. The proposed facility fulfills both criteria.

The system could be implemented in three sections:

- 1) Development of a waste oil collection system
- 2) Development of pre-treatment and storage systems. The systems are closely related in use and proximity.

The centrifuge supplier should be notified immediately of any decision to proceed. A longer lead time is desirable for the purchase of used equipment.

- 3) Purchase and installation of the boiler and rotary cup burner. Both components are available through Volcano Inc., Edmonton. Either a Saacke or Hamworthy burner may be specified. Delivery time for either burner is 14 weeks.

12.3 ENVIRONMENTAL MONITORING PROGRAM

The Environmental Protection Service (EPS) of Environment Canada have indicated an interest in guiding a program for monitoring hazardous contaminants in the fuel. The intention is to set standards of performance for similar installations at other northern locations.

Two approaches can be made to the monitoring program:

- 1) Sampling and analysis for specific known contaminants.
- 2) Sampling for all contaminants possible, and determine what is present.

The second approach is far more involved and as a consequence, far more costly.

Sampling for the known contaminants may prove to be difficult. In the air quality impact modelling, the maximum 30 day concentration was often less than 1 ug/m^3 .

The following recommendations are made:

- 1) Sample and analyse for the known toxic or carcinogenic contaminant metals in waste oil: arsenic, barium, cadmium, chromium, lead and zinc.
- 2) Sample and analyse for halide acids.
- 3) Sample and analyse for chlorinated organics in the emissions if supported by the presence of chlorinated organics in the fuel.

The effect of demulsifiers and centrifuging on the level of contaminants in waste oil was not quantified in any of the

used lube oils may be to increase removal of contaminant metals. This was not documented in literature reviewed.

The effect of water removal by decanting and centrifuging in relation to contaminant levels for chlorinated organics or total chlorine was not documented in literature reviewed.

The following recommendations, to be included in the monitoring program, are made:

- 4) Sample collected waste oil for all contaminants at:
 - i) the front end of the pre-treatment system (receiving tank),
 - ii) before the centrifuge, and
 - iii) bulk fuel storage.

This will establish the effectiveness of decanting, demulsifiers, centrifuging, for removal of contaminants.

- 5) Sample all residues for all contaminants to determine 'safe' and economic disposal methods.
- 6) Sample stack gas and ambient air for contaminants noted in the fuel (from bulk fuel storage).

Establish the relationship of contaminant emissions to concentration of contaminants in fuel (eg. 50% lead in fuel emitted). Also establish the relationship of contaminants in fuel to the total weight of particulate in stack gases.

The waste oil collection system should be sampled initially for PCB's. If PCB's are found to occur in the system, the source should be determined immediately. If no PCB's are detected, the issue may be set aside.

If there is a decision made to test for formation of dibenzodioxins and dibenzofurans, the fuel should be sampled and

analyzed for presence of these compounds and precursors to their formation.

13.0 WASTE OIL GENERATION AT OTHER LOCATIONS IN THE NORTH

13.1 GENERAL

The sources of waste oil at other locations in the north are similar to the sources at Hay River: transport sector (road, marine, aviation), utility (Northern Canada Power Commission), mining and government agencies. Several northern locations have been identified where it is felt that the annual waste oil production is sufficient to support a heat recovery project such as described in section 7.6 for Hay River.

Recovery rates for various sectors can be assumed as follows (Ref. 2):

automotive	53%
rail	30%
marine	53%
farming & mining	50%
industrial	30%

The major factor which has a negative impact on recovery of used oils is dispersion of sources in remote or isolated areas.

13.2 INDUSTRIAL GENERATION OF WASTE OIL

Significant volumes of waste oil are generated in the Beaufort area (oil company activity and transportation) and near Yellowknife (mining and transportation). Waste oil generation at Pine Point is discussed in Section 2.6.

Waste oil production in major industrial sectors is discussed in following sections. Communities with large population base and/or transportation sectors have also been identified.

Mining Industry

Some mines in the Northwest Territories were contacted and asked to estimate their annual generation of waste oil. Results are shown in Table 13.2-1.

TABLE 13.2-1 GENERATION OF WASTE OIL BY MINES IN N.W.T.

Mine Site	Estimated Volume Waste Oil (litres/yr)
Terra Mines Ltd.	200,000
Echo Bay Mines Ltd.	200,000
Giant Yellowknife Mines Ltd	100,000
Cominco Ltd. (Yellowknife Con Mine)	60,000

Terra Mines indicated that used oil was spread on the runway. Echo Bay Mines estimated 40-50% of waste oil generated was incinerated, 50-60% was shipped to Edmonton for rerefining. Giant Mines has no use for used oil and the oil is stockpiled. The Con Mine has used some oil for road oiling (30%) and has incinerated the balance (70%).

Both the Con and Giant Mines burn Bunker C for power generation. Neither company burns waste oil in a blend with the Bunker although it is found to be common practice in the United States (Ref. 1).

Terra Mine Ltd. is presently opening a pilot plant for a gold mining and milling operation (February 1985). The Bullmoose Mine is located 43 miles east of Yellowknife. Waste oil will be generated during the pilot phase and during operation.

Northern Canada Power Commission (NCPC)

NCPC is responsible for all power generation in the north with the exception of the Northland Utilities franchise in the Hay River region.

Table 13.2-2 shows the purchased volumes of recoverable petroleum products for NCPC power generation facilities. Attempts to determine disposal practices of waste oil by NCPC were unsuccessful.

TABLE 13.2-2: PURCHASED NON-FUEL PETROLEUM PRODUCTS AND
ESTIMATED RECOVERY - NCPC

POWER GENERATION AREA	LUBE OIL		NON-OIL		TOTAL
	bbl/yr	litre/yr 50% rec.	bbl/yr	litre/yr 80% rec.	litre/yr recoverable
Frobisher Bay	260	20,800	40	5,100	25,900
Cambridge Bay	132	10,600	48	6,100	16,700
Fort Simpson	132	10,600	20	2,500	13,100
Norman Wells	35	2,800	25	3,200	6,000
Inuvik	477	38,200	72	9,200	47,400
Rankin	225	18,000	57	7,300	25,300
Resolute	172	13,800	36	4,600	60,400
Talston: Fort Smith, Pine Point, Fort Resolution	176	14,000	10	1,300	15,300
Yellowknife	120	9,600	35	4,500	14,100
Yukon	95	7,600	10	1,300	8,900

1 bbl = 160 litres

Beaufort Area

The oil companies with major operations in the Beaufort were contacted regarding generation and disposal of waste oil. Large volumes of slops are generated in the area, with very high water contamination (75%). Other contaminants in the waste are crude oil from testing, drilling muds and solvents.

Used oils, which may or may not be segregated from other wastes, are used as dust suppressants in camps and communities. Other wastes are incinerated at Tuktoyaktuk base by Dome and burned for heat recovery onboard the Dome Explorer II and the Gulf Beaufort Ships.

Significant volumes of waste oil are available in the Beaufort area. During 1984, Dome Petroleum disposed of or put aside almost 200,000 US gallons (over 730,000 litres) of decanted (water free) waste oil.

Dome - Shore Operations

At Tuktoyaktuk base, Dome operate a Saacke burner for slops disposal. Slops generation for 1984 are given in Table 13.2-3.

TABLE 13.2-3: SLOPS GENERATION AT TUKTOYAKTUK BASE
(DOME PETROLEUM, 1984)

Slops Received	3,020,500 litres
Water Decanted	2,286,900
Slops Burned	515,700
Slops Used for Other Purposes	167,800
Volume on Hand	50,100

There is a high demand for used lube oil in the area as a dust suppressant and as a rust inhibitor for drill pipe. The 167,800 litres designated as being used for other purposes is used in these applications. The volume on hand, 50,100 litres, was identified as used oil and will likely be used for the same applications.

All waste oil is allowed to settle prior to incineration. This allows crude separation of oil and water phases. The Saacke burner is capable of handling oil with high water content (eg. 60% water), but capacity is reduced and steam is a major by-product of the combustion. If the decanted water is clear, it is directed to Tuktoyaktuk Harbour. If the water is dirty, the water is evaporated in front of the burner. This is the only residue noted by Dome.

No permits are required for operation of the Saacke burner at Tuktoyaktuk base. The unit is described as 'clean burning' and claims complete combustion. No emission tests have been done.

The Saacke burner has been used for the disposal of clean up from oil spills. A charge of 50 cents/gallon (before decanting) is made for disposal of spills and other wastes not generated by Dome. Operation of the unit is highlighted in Section 4.2. (Ref. 23)

Dome - Marine Operations

Waste oil is being burned for heat recovery on board the ship Explorer II. There are two Eclipse boilers with Saacke burners, rated at 10 million BTU/hour (2,929 kw). The units are capable of burning 100% waste oil if the volumes are available. An estimate of 30% waste in the boiler feed was made. Another estimate indicated waste comprised 5% of the boiler feeds.

No permits are required for operation of the units on the ship.

Water removed from the waste is treated in a two-stage oily water filter and discharged to the ocean in concentration levels of 15 ppm, meeting International Standards. No flue gas analysis is done for emissions.

Gulf (Beaudril) - Shore Operations

Gulf indicated that though they have a Saacke burner at Herschel Island for disposal of waste oil, the unit is not in use. Waste oil is burned for heat recovery on board ships and used for dust control in camp and by the communities of Aklavik, Tuktoyaktuk, and Inuvik.

Volumes of waste at Herschel Island were not identified. 500 drums (85,000 litres) of slops were apparently stockpiled at Herschel Island over the 1983-84 winter season. The drums were transported to Tuktoyaktuk in spring of 1984 and given to the communities for dust control.

Gulf (Beaufort) - Marine Operations

The ship Gulf Beaufort has burned waste oil for heat recovery. The waste is blended with diesel fuel prior to burning. An estimated 500,000 litres of used oil and slops were burned. The slops tank on board the Beaufort is heated to enhance oil/water separation. Decanted water is discharged to the ocean, or possibly treated in an oily bilge separator. Sludge generated in the slops tanks is disposed of in an incinerator on board.

The Gulf Beaufort receives oily slops from other ships. Aboard the Kiggiak and rig ships, small volumes are incinerated.

13.3 URBAN CENTRES

Yellowknife

There are several mines located near Yellowknife and significant volumes of waste oil are potentially available.

The GNWT Motor Vehicles Branch has 5630 automobiles and trucks registered at Yellowknife. At an estimated 8-10 litres per vehicle/year, an excess of 45,000 litres used oil is available. 240 truck tractors and 217 truck trailers are registered at Yellowknife. If all vehicles were serviced at Yellowknife, the volume of used oil available can be estimated as follows:

$$240 \text{ trucks} \times 90 \text{ l./veh./mo.} \times 10 \text{ mo.} = 216,000 \text{ litres}$$

The actual volume of used oil generated by the trucking industry at Yellowknife is not known.

The total volume of waste oil potentially available from the mines near Yellowknife is estimated to be 160,000 litres per year. NCPC generation of waste oil at Yellowknife is estimated to be 14,100 litres.

The total volumes of waste oil potentially available at Yellowknife are given in Table 13.3-1

TABLE 13.3-1: WASTE OIL POTENTIALLY AVAILABLE AT YELLOWKNIFE

<u>Source</u>	<u>Volume (litres)</u>
Automotive	45,000
Trucking Industry (assumed)	40,000
Mining	160,000
NCPC	14,000
TOTAL	259,000 litres

Other volumes of waste oil would be from the aviation and marine transport sectors. Contaminated fuels would also be available.

Pine Point

In Section 2.6, a waste oil volume in excess of 475,000 litres/year was estimated to be generated at Pine Point. Most of this oil is produced by Cominco Mines at Pine Point, and is used for dust suppression on haul roads.

Beaufort Area

The oil companies which are active in the Beaufort area produce significant volumes of waste oil each year. A separate survey is suggested to determine volumes and types of waste oil generated in the area. A project similar to this report, could outline suitable applications for utilization of the waste oil as a fuel.

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APPENDIX A

WASTE OIL PRODUCED BY VARIOUS HAY RIVER AREA FIRMS

75-80% of the waste generated at Hay River oil has been identified at the source:

Northern Transportation Company Ltd. (NTCL)

NTCL is the larger of the two marine transport companies at Hay River. In 1983, they moved in excess of 80 million litres of fuel and oils out of Hay River, and an additional 80 million litres out of Norman Wells.

Both barge companies generate contaminated fuels in three situations, for example when the

- 1) tank is cleaned;
- 2) tank is to be repaired, and must be made suitable for hot work;
- 3) product in barge is electrically charged.

NTCL had a high incidence of fuel contamination, during 1983 and 1984. Over 450,000 litres of fuel were reclaimed to be again suitable for use as fuel. What is not reclaimed is designated as 'slops' and stored in slops tanks until disposal. Slops generated by NTCL in 1984 are given in Table A-1.

TABLE A-1: SLOPS GENERATION BY NTCL (1984)

<u>Fuel Type</u>	<u>Slops Generation (litres)</u>
Diesel	46,461
Turbo	31,391
Gas	<u>17,433</u>
Total	95,285

The water content of slops is very high, 40-60% is common. The water may be washdown water from the barges or it may result from the tanks being open to the atmosphere.

The contaminated fuels have no value to NTCL. Currently, they are given to the Ministry of Transport (MOT) for airport fire fighting training sessions and to the Town of Hay River for burning in the sewage lagoon. The major contaminant in the fuel is water which must be removed prior to burning.

When surveyed, NTCL indicated they produced 25-50,000 litres of used oil per year. The volume seemed low in comparison to the oil generated by a smaller competitor, Arctic Transportation Ltd. (50,000 litres). NTCL was asked to confirm the volume. They indicated that lubricating oil purchases were approximately 500,000 litres. If used oil recovery from marine operations is estimated to be 53% (Ref 2); then 265,000 litres/year of used oil would be generated by NTCL.

Turbo Resources Refinery at Edmonton was contacted to determine the quantity of used oil NTCL has returned to Edmonton. Turbo reported 31,300 litres (7000 gallons) during May/June, 1984; 55,000 litres (12,000 gallons) during August/September, 1983. A volume of 45,000 - 68,000 litres (10,000-15,000 gallons) has been assumed for NTCL used oil generation.

NTCL plans to implement a bulk lubricating oil handling system (lube cubes) in 1985. Oil is to be returned to Edmonton for re-refining. The intent is to cut down on handling requirements of used oil. Currently, lubricating oil is contained in drums and must be loaded and unloaded from barges. High water contamination of used lube oil at NTCL was evident during sampling and has also been noted by the Turbo Refinery.

After the bulk lube oil system is in place at NTCL, the lube oil will have a value equivalent to the price a rerefinery would pay for the oil (FOB Hay River).

Arctic Transportation Ltd. (ATL)

ATL is a marine transport company at Hay River. Their major operations are in the Beaufort area. The Hay River based operation is much smaller than NTCL.

The volume of contaminated fuels generated by ATL (27,000 to 32,000 litres/year) is significantly less than that generated by NTCL (90,000 litres). Like NTCL, ATL has assigned no value to the contaminated fuel, and it is given to MOT and the Town of Hay River.

ATL also has assigned no value to used lubricating oil. During the summer and fall of 1984, ATL gave this waste oil to Bassett Trucking who sold the used oil to the Turbo Refinery at Edmonton.

The Hay River Operations Manager indicated that ATL would return used oil from the Beaufort to Hay River if there was a use for the oil. His main concern was that the drums be emptied of the oil prior to off-loading from the barge. This would make the drums easier to handle and reduce wear and tear on the drums which have a deposit value of \$25.00.

Northland Utilities (NWT) Ltd.

Northland Utilities operate the community power plant at Hay River. Used lubricating oil volume generated is 19,000 litres in a good year, higher (22,700 litres) in bad years. Peak generation times are spring and fall.

Transformer oils are of special concern due to possible contamination with PCB fluids. Northland Utilities have indicated they operate no PCB laden equipment at Hay River.

This was confirmed by Environment Canada who maintain a national inventory of PCB's. There are no stocks of PCB's at or near Hay River. Northlands Utilities indicated that the total volume of waste transformer oils generated was less than 100 litres per year.

There is some contamination in the Northlands Utilities used oil. These include glycol, engine filings, rags, etc. (anything which cannot be sewerred). Segregation of these wastes was considered possible.

Automotive

A portion of automobile sales and service centres were surveyed. Based on their responses, a total of 22,700 litres of automotive used lubricating oil was estimated to be available at Hay River per year.

The GNWT Motor Vehicles Branch was contacted for vehicle registrations at Hay River - their records indicated:

Cars	915
Taxi	11
Station Wagon	106
Trucks	<u>1557</u>
Total	2589

Assuming 8-10 litres per year of recoverable oil per vehicle, the volume of used oil from automotive sources is estimated to be 20,700 to 25,900 litres/year, confirming the survey.

The volume of 22,700 litres available may be a low estimate of automotive used oil available. Used oil generated by "do-it-yourselfers" is not considered available and will balance the low estimate.

The used oil from this sector is the only oil which will be contaminated with lead. All other lubricating oils are used in diesel engines.

Truck Transport Industry

The total volume of used oil available from the truck transport industry was also estimated on the basis of the few companies surveyed. A total of 53,500 litres/year used oil is estimated to be available at Hay River.

GNWT Motor Vehicles Branch figures do not support this estimate. There are 164 truck tractors and 513 truck trailers registered at Hay River. A truck can generate 90-100 litres used oil per month:

$$164 \times 90 \text{ litres/mo.} \times 10 \text{ mo./year} = 148,000 \text{ litres/year}$$

Many of the trucks registered at Hay River are serviced in Edmonton or at other locations. The lower volume of 53,500 litres has been used in assessing the total volume of used oil available.

It is assumed that most used oil generated in the trucking industry at Hay River is used for dust control in private yards. One firm surveyed indicated that the oil was disposed of at the Town dump.

Heavy Duty Equipment - Sales and Service

There are two heavy equipment businesses at Hay River, R. Angus and Fergusson Supply. Used oil generation rates are 11,000 litres and 7,000 litres per year respectively.

Neither company has assigned a value to the used oil. At R. Angus, the oil is drained to the sump and collected with septic/sewage removal. Some oil is used for dust control in yards. At Fergusson Supply the oil is used for dust control in the yard, but was considered to be in-effective.

Used oil is contaminated with hydraulic oils, transmission fluids, varsol, glycol, rags, etc. R. Angus indicated no particular interest in collecting the waste oil; only if storage was provided and no additional handling was required by mechanics.

Canadian Coast Guard

The Coast Guard runs a total of five vessels on the MacKenzie River system. The Nahatiuk is the largest of the vessels and is based at Tuktoyaktuk, although it is wintered (1984-85) at Hay River. The four smaller vessels work at Hay River to Wrigley, Wrigley to Little Chicago, Little Chicago to Tuktoyaktuk, and at Fort McMurray. Generally the smaller vessels winter at Fort McMurray, Fort Simpson and two at Hay River.

The total volume of used oil generated by the Coast Guard is in question. The Superintendent of planning and programming indicated a volume of 5-180 litres (1-40 gallons) per ship per year. This figure is thought to be extremely low in comparison to cars (8 litres/year) and truck tractor units (900 litres/year).

An unidentified source indicated that the Nahatiuk generates 30 drums used oil (5,000 litres) of oil at the spring change and 45 to 50 drums (7,500-8,500 litres) over the marine season. The four smaller vessels would generate less oil. A total of 200 drums (35,000 litres) was estimated to be available through the Canadian Coast Guard, but this figure is not confirmed.

GNWT Department of Highways

The volume of used oil generated by GNWT Department of Highways has not been satisfactorily assessed. When the survey was conducted at Hay River in October, 1984, volumes of 9,000 litres used oil and 1,500 litres solvent were indicated as the annual generation of waste oil. A total of 470 vehicles are operated from this base. This indicates an average of 20 litres lubricating oil per vehicle per year, and is considered to be a very low generation rate for an operation of this type (large numbers of heavy equipment, graders, snow removal equipment, etc.)

Several attempts were made to confirm the volume of oil generated by GNWT Department of Highways with no success. Inquiries regarding purchased volumes of non-fuel petroleum products were also left unanswered. The figure 10,500 litres per year, as reported by Highways during the survey, was used in the Hay River waste oil volume estimates.

During the summer months, GNWT Department of Highways has used used oil for road oiling. 'A district road 5 miles south of town' was the only road identified as being treated for dust suppression by GNWT Department of Highways. During winter months, used oil was hauled to the dump for burning. The waste oil not required for the road (8,200 litres) was indicated to be available to the town for the proposed facility.

Town of Hay River

When first surveyed, the Town of Hay River included a generation of 1,400 litres used oil annually. The Town had no use for the oil and it was stored in drums and burned at the town dump.

Many producers of used oil in town indicated that they disposed of their oil in the same manner ie. the clay pit at the town dump

where it was burned periodically. An attempt was made to determine the approximate total volume of used oil disposed of in this matter. It was then discovered that in fact very little oil is burned at the clay pit. Most used oil designated as disposed of at the dump, is stored in a 15,000 gallon tank owned by the Town. The oil is subsequently used for road oiling by the Town.

Bulk Plants

Contaminated fuels are occasionally generated by the bulk plants. If the fuel cannot be reclaimed it is donated to the Ministry of Transport or the Town of Hay River. The volumes are irregular and are not included in the survey.

Fuel and oil drums are returned to the bulk plant for container refund (\$25.00 deposit). Often, small quantities of fuel and oil remain in the drums. The small volumes are collected into drums and designated 'retain'.

The Esso Bulk Plant at Hay River (the NWT depot for all Esso drums) indicated an approximate volume of 50 drums (9,000 litres) retain annually. The waste is too messy for rerefining and is disposed of in Edmonton. The other bulk plants are estimated to generate 7,000 litres (1,500 gallons) retain annually.

Freshwater Fish Marketing Corporation

A total volume of 900 litres is generated by the local Fishplant per year. This volume includes oil generated in the plant and in the vessel 'Broadhead'.

Other

Canadian National Railways maintenance is performed at Peace River and no used oil is generated at Hay River. A total volume of 14,000 litres is generated at Peace River. The used oil is collected in 45 gallon drums and reportedly used for secondary lubrication (switches).

Both DIAND Forestry and the Canadian Coast Guard are producers of contaminated fuels. The volumes are irregular and are given to MOT for fire training. No consideration is given to these volumes in determining the waste oil available at Hay River.

The airport manager indicated that the volume of waste oil generated by aviation companies was negligible.

Dry cleaning firms and printers are producers of waste solvents. These firms were not contacted during the survey.